Published in final edited form as:

J Phys Act Health. 2016 May ; 13(5): 461–466. doi:10.1123/jpah.2015-0404.

Change in Physical Activity and Sedentary Time Associated With 2-Year Weight Loss in Obese Adults With Osteoarthritis

Christine A. Pellegrini, Jing Song, Rowland W. Chang, Pamela A. Semanik, Jungwha Lee, Linda Ehrlich-Jones, Daniel Pinto, and Dorothy D. Dunlop

Feinberg School of Medicine, Northwestern University, Chicago, IL. Pellegrini, Lee, and Chang are with the Dept of Preventive Medicine; Song is with the Institute of Public Health and Medicine; Dunlop is with the the Dept of Medicine; and Pinto is with the Dept of Physical Therapy

Christine A. Pellegrini: c-pellegrini@northwestern.edu

Abstract

Background—We examined if changes in moderate-to-vigorous physical activity (MVPA), light activity, and sedentary behavior are related to weight change over a 2-year period in obese adults with/elevated risk for knee osteoarthritis.

Methods—Weight, physical activity, and sedentary time at baseline and 2 years were obtained from 459 obese participants from the Osteoarthritis Initiative. Weight change was categorized as 10 lbs, 5.0 to 9.9 lbs, 4.9 to –4.9 lbs, –5.0 to –9.9 lbs, and –10 lbs. We examined the association between 2-year weight change categories and changes in activity/sedentary time from accelerometer monitoring by multiple linear regression adjusted for baseline weight, demographic, and health factors.

Results—Across the 5 weight categories (loss to gain), average 2-year change ranged from –7.4 to 28.0 sedentary minutes/ day, 4.2 to –23.1 light activity minutes/day, and 3.2 to –4.9 MVPA minutes/day, respectively. Higher weight loss categories were separately associated with increased MVPA (P for trend < 0.001) and less sedentary gain (P for trend = 0.01). Weight loss categories had a strong trend with light activity gain but not statistically significant (P for trend = 0.06).

Conclusions—Small increases in MVPA and decreases in sedentary time over 2 years were associated with weight loss among adults with obesity and with or at elevated risk for knee osteoarthritis.

Keywords

accelerometry; obesity; health behavior

Obesity is an established risk factor for the onset and progression of knee osteoarthritis (OA).^{1,2} As the prevalence of obesity in the United States remains elevated,³ obesity-related knee OA is expected to rise. Although the mechanism linking obesity with the development and progression of OA is complex, one assumption remains that excess weight increases the mechanical load on the knee, leading to the degeneration of cartilage.⁴ Not only does the severity of knee OA influence patient-reported pain and physical function, but body weight also can exacerbate pain. Higher body mass index (BMI) is associated with higher levels of OA pain, even after controlling for severity of OA.⁵

Weight loss can help to lower the risk of the development and progression of knee OA. Specifically, over a 10 year period, weight losses of at least 5 kg reduced the risk of developing knee OA by 50%.⁶ Weight loss is also frequently recommended as a treatment option for those with knee OA.⁷ While each pound lost relates to a 4-fold reduction in the knee joint load,⁸ weight losses of at least 10% of initial weight demonstrate the greatest improvements on knee joint loads.⁹ Diet-induced weight loss provides beneficial changes to adults with knee OA; however, the addition of physical activity to a weight management program not only enhances weight loss, but also leads to lower levels of pain and improved physical function.¹⁰ Higher levels of physical activity, even without weight loss, are associated with reduced pain, improved physical function and quality of life.^{11–13}

Significant weight losses and high levels of physical activity provide substantial benefits for those with knee OA, but achieving both tasks are challenging. For instance, among adults with symptomatic knee OA, 7 of 8 men and 10 of 11 women fail to meet activity guidelines.¹⁴ While engaging in moderate-to-vigorous intensity activity (MVPA) is important, identifying additional approaches to assist with weight management may provide persons with knee OA alternative effective strategies. One such approach may be increasing light-intensity physical activity (eg, pushing a grocery cart) and decreasing sedentary behaviors, such as sitting, which corresponds with the 2008 Physical Activity Guideline recommendations to avoid inactivity.¹⁵ Adults in the U.S. spend the majority of their day engaged in sedentary behavior.¹⁶ Excess sedentary time has been detrimentally linked to health,^{17,18} but its role in weight management, particularly among those with knee OA is unknown.

The purpose of this study is to examine the association between changes in objectively measured physical activity and sedentary behavior and weight change over a 2 year period in adults with obesity and with or at elevated risk of developing symptomatic knee OA. We hypothesized that increases in MVPA would be associated with weight losses, whereas increases in sedentary time would be linked with weight gains over the 2 years.

Methods

Study Population

The study population was a subcohort from the Osteoarthritis Initiative (OAI). The OAI is a multisite longitudinal study that enrolled 4796 adults between the ages of 45 to 79 years. Adults eligible for the OAI were either required to have symptomatic radiographic osteoarthritis in at least 1 knee (a definite tibiofemoral osteophyte [osteophyte grade 1]¹⁹ and pain, aching, or stiffness on most days for at least 1 month during the past 12 months) or were required to have at least 1 from a set of established knee osteoarthritis risk factors, which included being overweight. Full eligibility criteria for the Osteoarthritis Initiative are listed elsewhere.²⁰ Institutional review board approval was obtained at each of the 4 clinical sites (Baltimore, MD; Columbus, OH; Pittsburgh, PA; and Pawtucket, RI).

Participants for the current study included a subcohort of adults enrolled in the Osteoarthritis Initiative accelerometer study,¹⁴ which took place at the Osteoarthritis Initiative 48-month follow-up visit (baseline). The sample used for the current analyses includes participants

who met the following criteria: (1) obese (body mass index ≥ 30 kg/m²) at baseline, (2) ≥ 4 days of valid accelerometer monitoring at both baseline and 2 years, (3) completion of baseline and 2-year follow-up for body weight and covariates (Osteoarthritis Initiative study 48- and 72-month follow-up visits, respectively).

Measures

Physical Activity and Sedentary Behavior—Physical activity and sedentary behavior were objectively-measured at baseline and 2 years using ActiGraph GT1M accelerometers (ActiGraph, Pen-sacola, FL). Participants were instructed to wear the accelerometer at the natural waistline on the right hip during waking hours for 7 consecutive days. Using previously established methodology for this population,²¹ we processed all accelerometer data. We restricted analyses to participants with at least 4 days of valid wear time (≥ 10 hours/day) at both baseline and 2 year assessments.²² Nonwear time was defined as ≥ 90 minutes with zero activity counts, allowing for up to 2 minutes of < 100 counts. Sedentary time was defined as less than 100 counts per minute.²³ Counts per minute between 100 to 2019 were classified as light intensity physical activity and counts 2020 or greater were defined as MVPA.²² The time spent in sedentary and physical activity for each given day was standardized to 16 waking hours. The percentage of wear time was calculated and then standardized time spent in sedentary behavior, light intensity activity, and MVPA to a typical 16 hour waking day were determined (ie, standardized sedentary hours = % sedentary time $\times$ 16 hours).

Body Weight and Covariates—Body weight was assessed at baseline and 2 years. Covariates were measured at the baseline visit. Demographic and socioeconomic factors included age, sex, race/ethnicity, education, and income. The health factors examined included comorbidities, depressive symptoms, smoking status, knee OA severity, symptoms, and knee and other extremity pain. The Charlson Comorbidity Index assessed comorbidities.²⁴ Depressive symptoms were assessed using the Center for Epidemiological Studies Depression scale.²⁵ Knee OA severity was determined from the highest Kellgren-Lawrence grade of both knees²⁶ and pain was assessed using the Western Ontario and McMaster University osteoarthritis (WOMAC) pain index score of both knees. Knee symptoms were defined as having in either knee “pain, aching, or stiffness on most days of a month during the past year.” Pain in other extremities included the hip, ankle, and foot.

Statistical Analyses

Participants were categorized based on 2-year weight change: ≥ 10 lbs, 5.0 to 9.9 lbs, 4.9 to -4.9 lbs, -5.0 to -9.9 lbs, ≤ -10 lbs. Baseline characteristics were examined by weight change category. Multiple linear regression was used to examine the separate association of 2-year changes in sedentary behavior and physical activity with weight change categories in adults with obesity and with or at elevated risk for developing symptomatic knee OA. Analyses were first adjusted for baseline age and gender. Additional adjustment factors in the second model included baseline weight, demographic and socioeconomic factors (age, gender, race, education, and income) and health factors (comorbidity, depression, smoking, Kellgren-Lawrence grade, WOMAC pain, knee symptoms, knee injury, and lower extremity

pain). All analyses were performed using SAS software, version 9.3 (SAS Institute, Cary, NC).

Results

The distribution of baseline characteristics across 2-year weight change categories are presented in Table 1. Overall, participants were primarily White (81%), female (55%), had completed some education after high school (86%), and had at least 1 comorbidity (33%). Participants had a mean age of 63.3 ± 7.9 , weight of 209.1 ± 28.7 lbs, and BMI of 33.4 ± 2.9 kg/m² at baseline. Over 2 years, 32% of participants lost ≥ 5.0 lbs, 42% maintained weight (± 5 lbs), and 26% gained ≥ 5 lbs. At baseline, participants who lost at least 10 lbs over the 2 years tended to weigh more and engage in more sedentary behavior than those in the other 4 weight change categories.

The 2-year unadjusted changes in daily standardized sedentary time and physical activity by weight change category are displayed in Figure 1. Participants who lost at least 10 lbs reduced their sedentary time and increased light and MVPA, whereas participants in the other 4 weight change categories showed increases in sedentary time and decreases in light and MVPA. These patterns remained in the regression analyses summarized in Table 2.

The adjusted 2-year changes in standardized sedentary time, light, and MVPA by the 5 weight change categories are presented in Table 2, first adjusted for age and gender, and then adjusted for baseline weight, socioeconomic, and health factors. Over the 2 years of follow-up, participants who lost at least 10 lbs reduced daily sedentary time by 7.1 minutes/day on average, while those who gained at least 10 lbs significantly ($P = .006$) increased sedentary time by 25.8 minutes/day after adjusting for all covariates. The remaining 3 weight change categories also increased their sedentary time by approximately 10 minutes on average, however those changes were not significantly different compared with the ≥ 10 lbs gain category. The test for linear trend of change in sedentary time and weight change category was statistically significant (P for trend = 0.011).

All weight change categories reduced light intensity activity during the 2-year follow-up, except those who lost at least 10 lbs. Change in light intensity activity was significantly different between those who gained at least 10 lbs and lost at least 10 lbs (1.8 minutes vs. -23.1 minutes, respectively, $P = .033$). A linear trend between the changes in light intensity physical activity and weight change was found when adjusting for age and gender; further adjustment for baseline weight, socioeconomic and health factors, attenuated the trend (P for trend = 0.06).

It is notable that increases in MVPA were associated with weight loss or maintenance, whereas decreases in MVPA were associated with weight gain after accounting for all socioeconomic and health factors. Similar to sedentary and light activity, the changes in MVPA between those who lost at least 10 lbs and those who gained ≥ 10 lbs was significant (5.2 minutes vs. -2.7 minutes, $P = .003$). A strong linear trend between change in MVPA and weight change group was found (P for trend < 0.001).

Discussion

This study examined whether changes in sedentary behavior, light intensity activity, and MVPA are associated with weight change over a 2-year period of time in adults with obesity and with or at elevated risk for knee OA. Consistent with our hypotheses, increases in MVPA and decreases in sedentary time over 2 years were associated with weight loss, even after adjusting for health and socioeconomic factors. Our results showed a similar but weaker relationship between changes in light intensity physical activity and 2-year weight change. Notably, those in the weight change category who lost at least 10 lbs over the 2 years had both greater increases in light and MVPA as well as decreases in sedentary time, as compared with those who gained at least 10 lbs.

Previous studies have linked self-reported physical activity with long-term weight change. Over a 4-year period, decreases in self-reported physical activity were associated with weight gain in healthy women without obesity.²⁷ Littman and colleagues²⁸ found related results among older adults, with increases in self-reported recreational physical activity over 10 years helping to prevent weight gain. Further, the association found between physical activity and weight change was stronger for adults with obesity as compared with adults at normal weight. Consistent with this previous evidence from self-reported measures of activity, the current study observed that increases in objectively measured MVPA were associated with 2-year weight change in adults with obesity and with or at high risk for developing knee OA. The results continue to highlight the role that increased activity may play in weight management among adults with obesity.

Sedentary time has received increasing attention over the years as evidence continues to emerge demonstrating the detrimental effects of sitting on health.^{17,18} The adults with obesity in the current analyses spent over 65% of the day (>10 hours) engaged in sedentary behavior. Further, over the 2-year period, the average amount of time engaged in sedentary behaviors increased for this obese cohort. Although the increases in sedentary time varied by weight change category, if this trend continues, it may result in even higher levels of sedentary behavior. This is disconcerting, particularly as recent reports suggest that each additional hour spent sitting contributes to \$126 more in health care costs per year.²⁹ The only participants that did not increase sedentary time in the current analyses were those who lost at least 10 lbs over 2 years.

Few studies have examined changes in objectively measured sedentary time and long-term weight change. Using self-report sedentary time, Mozaffarian and colleagues²⁷ found that for every hour spent watching TV, a weight gain of 0.31 lbs was observed over a 4-year period. These results are similar to those of the current study, suggesting that decreases in total sedentary time are associated with 2-year weight loss. Although the health and weight benefits of MVPA are well established,³⁰ providing alternative recommendations to reduce sedentary time, even by small amounts, may also be beneficial, not only for weight management, but also to improve overall health and function.^{31,32}

Greater changes in light intensity physical activity were not significantly associated with 2-year weight loss in the current study after adjusting for covariates, but a strong trend was

seen. Limited research has examined objectively measured light intensity physical activity and weight change; however emerging evidence highlights the benefits of replacing sedentary time with light activity.^{33–36} Particularly for those who struggle to meet MVPA recommendations, the 2008 Physical Activity Guidelines recommend avoiding inactivity.¹⁵ Light intensity physical activity has been shown to be inversely related to sedentary time;^{37,38} thus, replacing sedentary time with light activity may be a more feasible change for adults with obesity as well as with or at risk for knee OA and may help to maintain weight; however, future research is needed to further determine the role of light intensity physical activity and weight change in adults with obesity.

The strengths of this study include the use of objectively measured physical activity and sedentary behavior over a 2-year period, which adds strong evidence to the literature linking self-report activity and weight change. In addition, this study provides initial insight on the relationship between changes in physical activity and sedentary time long-term in adults with obesity and symptomatic knee OA. We also note limitations in our study. Sedentary time was obtained using uniaxial accelerometers, which cannot detect body position and posture to provide information on sitting and standing time.²³ Further, diet, which plays a major role in the determination of the body weight, was not monitored in this study. To better understand the role of physical activity and sedentary behavior on long-term weight change, additional data on caloric intake and diet quality are necessary to evaluate the individual contributions of both diet and activity. It is likely that decreases in activity without subsequent decreases in caloric intake would lead to weight gain. On the other hand, similar levels of weight loss could occur if an individual maintained activity levels over 2 years, but decreased caloric intake as a result of illness. Future studies should aim to include assessments of energy intake as well as energy expenditure. Lastly, we are unsure how participation in the general OAI study influenced behaviors, including MVPA and sedentary behavior, before participation in the OAI accelerometer substudy.

Conclusions

In sum, the results of the current study demonstrated that among adults with obesity as well as with or at risk for developing knee OA, small increases in MVPA and decreases in sedentary time were associated with weight loss over a 2-year period. Adults with obesity who lost at least 10 lbs over 2 years, had higher increases in light and MVPA as well as decreases in sedentary time as compared with those who gained more than 10 lbs. The findings support the continued recommendation of participation in MVPA for weight management and avoidance of inactivity in adults with obesity.

Acknowledgments

This study was funded in part by the National Institute for Arthritis and Musculoskeletal Diseases (P60-AR064464, R21-AR059412, R01-AR054155) and K12HS023011 from the Agency for Healthcare Research and Quality. This manuscript was prepared using the Osteoarthritis Initiative public use data set and the content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality, OAI investigators, or NIH.

References

1. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage*. 2010; 18(1):24–33. DOI: 10.1016/j.joca.2009.08.010 [PubMed: 19751691]
2. Zhou Z-Y, Liu Y-K, Chen H-L, Liu F. Body mass index and knee osteoarthritis risk: a dose-response meta-analysis. *Obesity (Silver Spring)*. 2014; 22(10):2180–2185. DOI: 10.1002/oby.20835 [PubMed: 24990315]
3. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *JAMA*. 2012; 307(5):491–497. DOI: 10.1001/jama.2012.39 [PubMed: 22253363]
4. Felson DT, Goggins J, Niu J, Zhang Y, Hunter DJ. The effect of body weight on progression of knee osteoarthritis is dependent on alignment. *Arthritis Rheumatol*. 2004; 50(12):3904–3909. DOI: 10.1002/art.20726
5. Weiss E. Knee osteoarthritis, body mass index and pain: data from the Osteoarthritis Initiative. *Rheumatology*. 2014; 53(11):2095–9. [PubMed: 24939675]
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. *Intern Med*. 1992; 116(7):535–539.
7. Zhang W, Moskowitz RW, Nuki G, et al. OARSI recommendations for the management of hip and knee osteoarthritis, part I: critical appraisal of existing treatment guidelines and systematic review of current research evidence. *Osteoarthritis Cartilage*. 2007; 15(9):981–1000. DOI: 10.1016/j.joca.2007.06.014 [PubMed: 17719803]
8. Messier SP, Gutekunst DJ, Davis C, DeVita P. Weight loss reduces knee-joint loads in overweight and obese older adults with knee osteoarthritis. *Arthritis Rheumatol*. 2005; 52(7):2026–2032. DOI: 10.1002/art.21139
9. Messier SP, Legault C, Loeser RF, et al. Does high weight loss in older adults with knee osteoarthritis affect bone-on-bone joint loads and muscle forces during walking? *Osteoarthritis Cartilage*. 2011; 19(3):272–280. DOI: 10.1016/j.joca.2010.11.010 [PubMed: 21134477]
10. Messier SP, Mihalko SL, Legault C, et al. Effects of intensive diet and exercise on knee joint loads, inflammation, and clinical outcomes among overweight and obese adults with knee osteoarthritis: the IDEA randomized clinical trial. *JAMA*. 2013; 310(12):1263–1273. DOI: 10.1001/jama.2013.277669 [PubMed: 24065013]
11. Dunlop DD, Song J, Semanik PA, Sharma L, Chang RW. Physical activity levels and functional performance in the osteoarthritis initiative: a graded relationship. *Arthritis Rheumatol*. 2011; 63(1):127–136. DOI: 10.1002/art.27760
12. Feinglass J, Thompson JA, He XZ, Witt W, Chang RW, Baker DW. Effect of physical activity on functional status among older middle-age adults with arthritis. *Arthritis Rheum*. 2005; 53(6):879–885. DOI: 10.1002/art.21579 [PubMed: 16342096]
13. Rejeski WJ, Focht BC, Messier SP, Morgan T, Pahor M, Penninx B. Obese, older adults with knee osteoarthritis: weight loss, exercise, and quality of life. *Health Psychol*. 2002; 21(5):419–426. DOI: 10.1037/0278-6133.21.5.419 [PubMed: 12211508]
14. Dunlop DD, Song J, Semanik PA, et al. Objective physical activity measurement in the osteoarthritis initiative: Are guidelines being met? *Arthritis Rheumatol*. 2011; 63(11):3372–3382. DOI: 10.1002/art.30562
15. US Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. 2008.
16. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behaviors in the United States, 2003–2004. *Am J Epidemiol*. 2008; 167(7):875–881. DOI: 10.1093/aje/kwm390 [PubMed: 18303006]
17. Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Intern Med*. 2015; 162(2):123–132.

18. Koster A, Caserotti P, Patel KV, et al. Association of sedentary time with mortality independent of moderate to vigorous physical activity. *PLoS One*. 2012; 7(6):e37696.doi: 10.1371/journal.pone.0037696 [PubMed: 22719846]
19. Altman RD, Hochberg M, Murphy WA Jr, Wolfe F, Lequesne M. Atlas of individual radiographic features in osteoarthritis. *Osteoarthritis Cartilage*. 1995; 3(Suppl A):3–70. [PubMed: 8581752]
20. Eckstein F, Wirth W, Nevitt MC. Recent advances in osteoarthritis imaging—the Osteoarthritis Initiative. *Nat Rev Rheumatol*. 2012; 8(10):622–630. [PubMed: 22782003]
21. Song J, Semanik P, Sharma L, et al. Assessing physical activity in persons with knee osteoarthritis using accelerometers: data from the osteoarthritis initiative. *Arthritis Care Res*. 2010; 62(12): 1724–1732. DOI: 10.1002/acr.20305
22. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *MSSE*. 2008; 40(1):181–188.
23. Healy GN, Clark BK, Winkler EAH, Gardiner PA, Brown WJ, Matthews CE. Measurement of Adults' Sedentary Time in Population-Based Studies. *Am J Prev Med*. 2011; 41(2):216–227. [PubMed: 21767730]
24. Katz JN, Chang LC, Sangha O, Fossel AH, Bates DW. Can comorbidity be measured by questionnaire rather than medical record review? *Med Care*. 1996; 34(1):73–84. DOI: 10.1097/00005650-199601000-00006 [PubMed: 8551813]
25. Pandya R, Metz L, Patten SB. Predictive value of the CES-D in detecting depression among candidates for disease-modifying multiple sclerosis treatment. *Psychosomatics*. 2005; 46(2):131–134. DOI: 10.1176/appi.psy.46.2.131 [PubMed: 15774951]
26. Peterfy C, Li J, Zaim S, et al. Comparison of fixed-flexion positioning with fluoroscopic semi-flexed positioning for quantifying radiographic joint-space width in the knee: test-retest reproducibility. *Skeletal Radiol*. 2003; 32(3):128–132. DOI: 10.1007/s00256-002-0603-z [PubMed: 12605275]
27. Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. Changes in diet and lifestyle and long-term weight gain in women and men. *N Engl J Med*. 2011; 364(25):2392–2404. DOI: 10.1056/NEJMoa1014296 [PubMed: 21696306]
28. Littman AJ, Kristal AR, White E. Effects of physical activity intensity, frequency, and activity type on 10-y weight change in middle-aged men and women. *Int J Obes*. 2005; 29(5):524–533.
29. Rosenberg D, Cook A, Gell N, Lozano P, Grothaus L, Arterburn D. Relationships between sitting time and health indicators, costs, and utilization in older adults. *Prev Med Rep*. 2015; 2(0):247–249. DOI: 10.1016/j.pmedr.2015.03.011 [PubMed: 26844078]
30. American College of Cardiology/American Heart Association Task Force on Practice Guidelines, Obesity Expert Panel 2013. Expert Panel Report: Guidelines (2013) for the management of overweight and obesity in adults. *Obesity* (Silver Spring). 2014; 22(Suppl 2):S41–S410. DOI: 10.1002/oby.20660 [PubMed: 24227637]
31. Lee J, Chang RW, Ehrlich-Jones L, et al. Sedentary behavior and physical function: objective evidence from the Osteoarthritis Initiative. *Arthritis Care Res*. 2015; 67(3):366–373. DOI: 10.1002/acr.22432
32. Semanik PA, Lee J, Song J, et al. Accelerometer-monitored sedentary behavior and observed physical function loss. *Am J Public Health*. 2015; 105(3):560–566. DOI: 10.2105/AJPH.2014.302270 [PubMed: 25602883]
33. Dunstan DW, Kingwell BA, Larsen R, et al. Breaking up prolonged sitting reduces postprandial glucose and insulin responses. *Diabetes Care*. 2012; 35(5):976–983. [PubMed: 22374636]
34. Bailey DP, Locke CD. Breaking up prolonged sitting with light-intensity walking improves postprandial glycemia, but breaking up sitting with standing does not. 2015; 18(3):294–298. DOI: 10.1016/j.jsams.2014.03.008
35. Larsen RN, Kingwell BA, Robinson C, et al. Breaking up of prolonged sitting over three days sustains, but does not enhance, lowering of postprandial plasma glucose and insulin in overweight and obese adults. *Clin Sci*. Mar; 2015 129(2):117–127. [PubMed: 25731923]
36. Larsen RN, Kingwell BA, Sethi P, Cerin E, Owen N, Dunstan DW. Breaking up prolonged sitting reduces resting blood pressure in overweight/obese adults. *Nutr Metab Cardiovasc Dis*. 2014; 24(9):976–982. DOI: 10.1016/j.numecd.2014.04.011 [PubMed: 24875670]

37. Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003–06. *Eur Heart J*. 2011; 32(5):590–597. DOI: 10.1093/eurheartj/ehq451 [PubMed: 21224291]
38. Healy GN, Wijndaele K, Dunstan DW, et al. Objectively measured sedentary time, physical activity, and metabolic risk. *Diabetes Care*. 2008; 31(2):369–371. [PubMed: 18000181]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.
Two-year change in average daily time spent in sedentary behavior and physical activity based on 2-year weight change category

Table 1

Baseline Characteristics by Changes in Body Weight in Obese Adults With or at High Risk for Knee Osteoarthritis (n = 459)

Baseline characteristics (% or mean $\pm$ SD)	Baseline characteristics based on 2-year weight change category			
	10 lbs LOSS (n = 76)	5.0–9.9 lbs LOSS (n = 73)	4.9 lbs LOSS to 4.9 lbs GAIN (n = 193)	5.0–9.9 lbs GAIN (n = 67)
Socioeconomic (SES) factors				
Age (yrs)	63.6 (8.4)	64.3 (7.7)	62.7 (8.2)	63.7 (7.7)
Caucasian/other	81.6	82.2	79.3	82.1
Female	56.6	60.3	51.3	55.2
Post high school education	86.8	90.4	83.4	85.1
Lower income ^a	38.2	37.0	27.5	22.4
Health factors				
Body weight (lbs)	214.6 (28.8)	207.6 (31.0)	208.1 (29.4)	209.2 (23.8)
Presence of comorbidity ^b	39.5	28.8	30.1	34.3
High depressive symptoms ^c	14.5	16.4	11.4	14.9
Current smoker	2.6	4.1	1.0	4.5
Radiographic knee osteoarthritis ^d	35.5	38.4	29.0	44.8
Knee pain ^e	3.2 (4.0)	4.0 (3.6)	3.1 (3.3)	3.3 (4.1)
Knee symptoms ^f	47.4	53.4	48.7	43.3
Prior knee injury	52.6	57.5	43.0	50.8
Hip pain	60.5	68.5	51.8	59.7
Foot/ankle pain	19.7	26.0	16.6	25.4
Average daily time in physical activity ^g				
Sedentary minutes	664.7 (74.2)	647.2 (74.9)	649.4 (83.4)	643.0 (92.7)
Light activity minutes	283.7 (70.2)	299.5 (71.2)	294.9 (79.5)	300.8 (88.9)
Moderate-to-vigorous activity minutes	11.6 (12.3)	13.3 (14.3)	15.7 (14.9)	16.2 (14.7)

^aIncome less than \$50,000 per year.^bComorbidities include the report of cancer, cerebrovascular disease, congestive heart failure, diabetes, gastrointestinal disease, pulmonary disease, kidney problems, myocardial infarction, rheumatic disease other than osteoarthritis, vascular disease;^cCenter for Epidemiological Studies Depression score 16;

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

^d Radiographic knee osteoarthritis ascertained from Kellgren-Lawrence grade 2 in 1 or both knees;

^e Western Ontario and McMaster University Osteoarthritis Index pain score;

^f Affirmed pain, aching, or stiffness most days of the month past 12 months;

^g Time in each activity level for a given day, standardized to 16 waking hours.

Table 2

Adjusted 2-Year Change in Average Daily Time Spent in Sedentary Behavior, Light Activity, and MVPA Based on 2-Year Weight Change Category

Weight change category	Sedentary Minutes ^b		Light Activity Minutes ^b		MVPA Minutes ^b	
	Change adjusted for age and gender	Mean ± SE	Change adjusted for age and gender	Mean ± SE	Change adjusted for age and gender	Mean ± SE
10 lbs LOSS (n = 76)	-7.62 ± 7.83 *	-7.06 ± 9.25 *	3.51 ± 7.61 *	1.81 ± 8.98 *	4.11 ± 1.71 *	5.24 ± 2.02 *
5.0-9.9 lbs LOSS (n = 73)	9.16 ± 7.89	7.25 ± 9.25	-9.82 ± 7.67	-9.64 ± 10.54	0.66 ± 1.73	2.39 ± 2.02
4.9 lbs LOSS to 4.9 lbs GAIN (n = 193)	11.11 ± 5.53	9.13 ± 7.66	-11.09 ± 5.38	-10.55 ± 7.44	-0.03 ± 1.21	1.42 ± 1.67
5.0-9.9 lbs GAIN (n = 67)	10.19 ± 8.31	9.48 ± 9.42	-7.90 ± 8.08	-8.58 ± 9.15	-2.29 ± 1.82	-0.90 ± 2.06
10 lbs GAIN (n = 50) (Reference)	28.97 ± 9.48	25.82 ± 10.70	-23.94 ± 9.22	-23.09 ± 10.40	-4.02 ± 2.07	-2.72 ± 2.34
Pvalue (trend)	0.0055	0.0109	0.0375	0.0624	0.0005	0.0008

Abbreviations: MVPA, moderate-to-vigorous physical activity; SES, socioeconomic status.

^a Adjusting factors: SES (age, gender, race, education, income), Health (comorbidity, high depressive symptoms, smoking, K/L grade, WOMAC pain, knee symptoms, knee injury, hip pain, ankle pain, foot pain, baseline weight).^b Average minutes spent in each activity level for a given day, standardized to 16 waking hours.* Significant differences (at $P < 0.05$ level) in 2 year change of each activity by weight change categories compared with people with 10 lbs weight gain (reference).