Int J Clin Exp Med 2016;9(11):22282-22288
www.ijcem.com /ISSN:1940-5901/IJCEM0020214

*Original Article*

# Factors affecting the outcome of hemi hip arthroplasty in elderly patients with femoral neck fractures

Chen Xu[1*], Yuanqing Mao[1*], Lin Wang[2], Jiawei Xu[1], Zhenan Zhu[1]

*[1]Department of Orthopedics, Shanghai Key Laboratory of Orthopedic Implants, Shanghai Ninth People's Hospital, School of Medicine, Shanghai Jiao Tong University, Shanghai 200011, China; [2]Department of Orthopedics, The Yijishan Hospital of Wannan Medical College, Wuhu, Anhui 241002, China. [*]Equal contributors and co-first authors.*

Received November 16, 2015; Accepted April 18, 2016; Epub November 15, 2016; Published November 30, 2016

**Abstract:** The outcome of hemi hip arthroplasty is affected by many factors. Which factors may affect the outcome remains a controversial topic. The aim of this study was to assess the factors that may have the greatest influence on patients' postoperative outcome. 258 patients underwent HA from January 2006 to December 2012 were included, consisting of 187 women (72.5%) and 71 men (27.5%) with a mean age of 85.140 ± 4.370. Ordinal logistic regression analysis was used to analyze the related factors included postoperative complications and general conditions. Hip function was evaluated by Harris Hip Score. An older age (P = 0.007, odds ratio [OR] = 1.12) was associated with a lower postoperative HHS. A higher BMI (P = 0.005, OR = 1.22) was associated with a lower postoperative HHS. The ASA score (P≤0.001, OR = 3.23) of the high group was associated with a poor prognosis compared to the low group. When the patients had more comorbidities, they had poor functional outcomes (P<0.05, OR = 3.76, 8.81). Regarding patients with diabetes, joint function was worse postoperatively for those with diabetes than those without diabetes (P<0.001, OR = 1.19). Patients with an older age, a high BMI, a high ASA score, and more comorbidities may have a poorer functional outcome. In those with hypertension, CHD, diabetes, and COPD, the main negative factor affecting the prognosis is diabetes.

**Keywords:** Hemi hip arthroplasty, comorbidities, outcome

## Introduction

The morbidity of femoral neck fractures has increased in China. Although uncemented bipolar hemi hip arthroplasty has been widely used in clinical practice, the postoperative prognosis is not always satisfactory [1, 2]. The outcome of hemi hip arthroplasty is affected by many factors such as the patients' age, body mass index (BMI), and comorbidities. Inappropriate perioperative management affects the patients' postoperative rehabilitation. Therefore, treating femoral neck fractures in elderly patients should reduce the risk of surgery and meet the patients' basic functional demands. Presently, many studies have only focused on the outcome of total hip arthroplasty because of osteoarthritis [3-5]. There is a lack of research related to femoral neck fractures in elderly patients with complex conditions treated by hemi hip arthroplasty.

The aim of this study was to assess the factors that may affect the outcome in patients over 80 years who have experienced acute femoral neck fractures. We attempted to determine which factors have the greatest influence on patients' postoperative outcome.

## Materials and methods

This retrospective study was performed at a single hospital (Shanghai Ninth People's Hospital). The study was approved by our institutional review board, and informed consent was obtained from all patients. The inclusion criteria were age ≥80 years, acute femoral neck fractures caused by trauma, and the capacity to walk without walking aids before the fracture occurred. Uncemented bipolar hemi hip arthroplasty was performed as the main treatment. Patients with dementia or other mental disease and a general condition unsuitable for surgery were excluded from the study.

**Table 1.** Patients' general conditions

| Condition | |
|---|---|
| Total (n) | 258 |
| Sex (male/female) | 71/187 (27.5%/72.5%) |
| Age (years) | 85.140 ± 4.37 |
| BMI (kg/m$^2$) | 21.9 ± 3.27 |
| Anesthesia (general/spinal, n) | 239/19 |
| Comorbidity groups (1/2/3/4) | 68/95/54/41 |
| Comorbidities (n) | |
| Hypertension | 98 |
| Diabetes mellitus | 85 |
| COPD | 39 |
| CHD | 36 |
| ASA score (n) | |
| Low score group (Level I/II) | 192 (47/145) |
| High score group (Level III/IV) | 66 (59/7) |
| Time from fracture to operation (h) | 50.678 ± 7.215 |
| Operation time (min) | 48.236 ± 12.448 |
| Blood loss (mL) | 105.937 ± 37.219 |

Values are expressed as the mean ± standard deviation; n: number of patients; BMI: body mass index; COPD, chronic obstructive pulmonary disease; CHD: coronary heart disease; ASA: American Society of Anesthesiologists.

**Table 2.** The outcomes of patients postoperatively

| Postoperative complications | Patients, n | |
|---|---|---|
| Infection | 0 | |
| Dislocation | 3 | |
| Thromboembolism | 1 | |
| Periprosthetic fracture | 3 | |
| Prosthesis loosening | 0 | |
| Mortality (30-day/1-year) | 2/24 | |
| Harris Hip Scores* | | |
| Excellent | 56 | 94.61 ± 2.31 |
| Good | 169 | 88.38 ± 4.21 |
| Fair | 33 | 76.25 ± 4.16 |
| Total | 258 | 88.71 ± 8.62 |

*Values are expressed as the mean ± standard deviation.

Of all 443 patients with a femoral neck fracture from January 2006 to December 2012, 258 eligible patients were identified for this study, including 187 women (72.5%) and 71 men (27.5%) with a mean (standard deviation [SD]) age of 85.140 ± 4.370 years (range, 80-99 years).

The patients' general condition was considered, including their age, sex, BMI, preoperative waiting time, operation time, intraoperative bleeding, and preoperative comorbidities. The primary outcomes of follow-up included postoperative complications (e.g., infection, dislocation, and thromboembolism problems), re-operation for any reason, and mortality at 30 days and 1 year postoperatively. The patients' anesthesia grade was based mainly on the American Society of Anesthesiologists (ASA) score. In this study, we divided the ASA score into the low score group (levels I and II) and the high score group (levels III and IV).

Hip function was evaluated by the Harris Hip score (HHS). In this study, we divided patients into the excellent group (the score ranged from 90-100), good group (the score ranged from 80-89), and fair group (the score was <80).

To investigate the relationship between joint function and the postoperative comorbidities, we divided patients into four groups by the number of basic diseases: group 1 (no diseases), group 2 (only 1 disease), group 3 (two diseases), and group 4 (at least three diseases).

The data of different groups was analyzed by Chi-square analysis. Ordinal logistic regression analysis was used to find out which factors are influential in our study. All statistical analyses were performed on a personal computer using SPSS software for Windows (version 19.0; SPSS, Chicago, IL, USA). The incidence of patients' general condition, basic diseases, and HHS were analyzed using descriptive statistics. The relevant parameters were chosen based on the results of the parameters in the statistical database ($\alpha = 0.05$). Ordinal logistic regression analysis was used for parameters with $P<0.05$.

## Results

General data on the patients are shown in **Table 1**. The ASA scores were distributed as follows: level I, 47 cases (18.2%); level II, 145 cases (56.2%); level III, 59 cases (22.9%); and level IV, 7 cases (2.7%). The majority of patients (239; 92.6%) underwent hemi arthroplasty under general anesthesia, whereas 19 (7.4%) received spinal anesthesia. The mean (SD)

**Table 3.** Chi-square analysis of the patients' general condition

| Parameter | Excellent | Good | Fair | *P* value |
|---|---|---|---|---|
| Total | 56 | 169 | 33 | |
| Age (years) | 83.95 ± 4.00 | 85.05 ± 4.19 | 87.61 ± 4.93 | 0.001 |
| Sex (M/F) | 12/44 | 51/118 | 8/25 | 0.059 |
| BMI (kg/m$^2$) | 21.587 ± 2.38 | 22.410 ± 2.18 | 22.660 ± 2.32 | 0.034 |
| Waiting time (h) | 52.13 ± 8.19 | 49.26 ± 9.71 | 51.47 ± 7.78 | 0.094 |
| ASA (low/high) | 56/0 | 126/43 | 10/23 | <0.001 |
| Anesthesia (general/spinal) | 56/0 | 160/9 | 23/10 | <0.001 |
| Operation time (min) | 47.82 ± 8.21 | 49.29 ± 10.71 | 47.84 ± 10.62 | 0.539 |
| Operative bleeding (mL) | 100.45 ± 40.22 | 110.78 ± 36.38 | 104.31 ± 30.28 | 0.079 |
| Comorbidities (0/1/2/≥3) | 26/27/2/1 | 42/68/43/16 | 0/0/9/24 | <0.001 |

Values are expressed as the mean ± standard deviation; M: male; F: female; BMI: body mass index; ASA: American Society of Anesthesiologists; SE, standard error.

**Table 4.** Results of the ordinal logistic regression analysis

| | | β | SE | Wald | *P* value | OR (95% CI) |
|---|---|---|---|---|---|---|
| Excellent | | 15.99 | 3.83 | 17.41 | <0.001 | |
| Good | | 22.47 | 4.08 | 30.37 | <0.001 | |
| Age | | 0.16 | 0.04 | 7.20 | 0.007 | 1.12 (1.03, 1.22) |
| BMI | | 0.20 | 0.07 | 8.03 | 0.005 | 1.22 (1.06, 1.40) |
| ASA score | | 1.17 | 0.62 | 12.49 | <0.001 | 3.23 (2.63, 10.78) |
| Anesthesia | | 0.32 | 0.62 | 0.26 | 0.61 | |
| Comorbidity Group | 2 | 0.37 | 0.36 | 1.04 | 0.31 | |
| | 3 | 1.32 | 0.68 | 11.62 | 0.001 | 3.76 (2.69, 14.31) |
| | 4 | 2.18 | 0.78 | 28.90 | <0.001 | 8.81 (5.22, 40.41) |
| | 1 | 0[a] | | | | |

[a]: A benchmark for comparison, the coefficient of 0; BMI: body mass index; ASA: The American association of the anesthesiologist; CI: confidence interval; OR, odds ratio.

waiting time from fracture to operation was 50.678 ± 7.215 hours. The mean (SD) surgery time (from incision to closure) was 48.236 ± 12.448 min. Blood loss during the operation was 105.937 ± 37.219 mL. The mean (SD) BMI was 21.9 ± 3.27 kg/m$^2$. Sixty-eight patients had no basic diseases (26.4%), whereas 95 (36.8%) had one, 54 (20.9%) had two, and 41 (15.6%) had at least 3 diseases.

Among all 258 cases, no infection or wound healing problems were reported. Three patients (1.16%) had joint dislocation. One patient (0.38%) requested medical help because of deep venous thrombosis. Three patients (1.16%) underwent re-operations for periprosthetic fractures, all of which were caused by trauma. No prosthesis loosening was recorded on the basis of radiography findings during the follow-up (**Table 2**). Two patients died within 30 days after hip bipolar hemiarthroplasty. Twenty-four patients (9.3%) died within 1 year postoperatively from various causes: 6 cases of heart head blood-vessel, 6 of pulmonary infection, 3 of diabetes complications, 3 of renal insufficiency, 3 of a malignant tumor, and 1 of a traffic crash. The reason for death was unknown in 2 cases.

The HHS is shown in **Table 2**. The mean (SD) score was 86.71 ± 8.62 at the last follow-up. At the last follow-up examination, 56 patients scored over 90, with a mean (SD) of 94.61 ± 2.31, and 169 scored from 80-89 (mean [SD], 85.38 ± 4.21). Thirty-three patients scored lower than 80, with a mean (SD) of 76.25 ± 4.16.

A comparison of the parameters is shown in **Table 3**. There were statistically significant differences among the HHS groups for age, BMI, the ASA score, comorbidity groups, and the anesthesia method (all, P<0.05); the other parameters were not significant (all, P>0.05) (**Table 3**). There was no direct relationship between joint function and the method of anesthesia according to ordinal logistic regression analysis (P>0.05) (**Table 4**). An older age (P = 0.007, odds ratio [OR] = 1.12) was associated with a lower postoperative HHS. A higher BMI (P = 0.005, OR =1.22) was associated with a lower postoperative HHS. The ASA score (P≤

**Table 5.** Chi-square analysis of the four diseases

| Diseases | Excellent | Good | Fair | *P* value |
|---|---|---|---|---|
| Total | 56 | 169 | 33 | |
| Hypertension | 21 | 69 | 8 | 0.199 |
| Diabetes | 11 | 59 | 15 | 0.028 |
| COPD | 6 | 28 | 5 | 0.570 |
| CHD | 3 | 31 | 2 | 0.020 |

COPD: chronic obstructive pulmonary diseases; CHD: coronary heart disease.

0.001, OR = 3.23) of the high group was associated with a poor prognosis compared to the low group. The influence of the number of comorbidities on joint function postoperatively was significant. Compared with the groups of patients without diseases, there was no significant difference in patients with only one disease (P = 0.309). The *P* values of the comorbidity group 2 and comorbidity group 3 were <0.05. According to the OR (3.76, 8.81), when the patients had more comorbidities, they had poor functional outcomes.

The most common comorbidities were hypertension (98 cases), diabetes (85), chronic obstructive pulmonary disease (COPD) (39), and coronary heart disease (CHD) (36). The other diseases were not statistically significant. Therefore, they were excluded from the study. The results of diabetes and CHD (P<0.05) were statistically significantly different among the HHS groups according to the chi-square test (**Table 5**). However, ordinal logistic regression analysis showed that there was no direct relationship between CHD and the patients' outcomes (P>0.05). Regarding patients with diabetes, joint function was worse postoperatively for those with diabetes than those without diabetes (P<0.001, OR = 1.19) (**Table 6**).

## Discussion

Femoral neck fractures are common in the elderly. Currently, uncemented bipolar hemi hip arthroplasty has become the first line of treatment. However, the prognosis of elderly patients is still not as good as that for young patients, as there are still many problems [6]. Hawker [7] thought that the most important factor that affects the prognosis of elderly patients is the comorbidities. Other scholars have thought that age, obesity, and other factors affect patients' postoperative rehabilitation. The patients' quality of life of recovery is a complex process wholly influenced by multiple factors.

Elderly patients are different from young patients. They often have the following characteristics: 1. comorbidities: the elderly often have a variety of basic diseases before fracture such as hypertension; 2. a poor stress response: the elderly do not easily or quickly respond during an emergency; 3. poor recovery: the recovery function of the elderly is decreasing, which makes it difficult to restore their internal condition to a stable state; and 4. high mortality: functional degeneration causes elderly patients to have a lower life expectancy. Therefore, surgeons can restore the patient's hip function by using proper treatment, but the chain reaction of events during postoperative follow-up still greatly affects the patients' quality of life.

The most critical factor is comorbidities. Different diseases are widely considered a major factor affecting the patients' prognosis [7]. In this study, >73% of the patients had at least one kind of disease. The most common comorbidities were hypertension, diabetes, COPD, and CHD. The results showed that when patients had only one kind of disease, there was no difference in joint function compared to patients with no complications. As the number of diseases increased, the postoperative influence on joint function also increased compared with healthy patients. When only onecomorbidity exists, it can be compensated by the body's function in some way. Thus, the short-term follow-up after joint replacement was always good. However, the long-term follow-up may be poor. When complications exist together, the impact on the body's system may be mutual superposition. Particularly, in important systems, it may cause patients to lose their tolerance ability. Thus, the patients' prognosis after joint replacement is not ideal.

Diseases of the cardiovascular system are the main cause of postoperative complications. They account for 42-75% of malignant complications after joint replacement [8]. Parvizi [9] thought that in the process of surgery, due to intramedullary operation, the risk of bone marrow microemboli would increase. Thereby, it may aggravate heart burden, causing postop-

**Table 6.** Results of the ordinal logistic regression analysis

| | β | SE | Wald | *P* value | OR (95% CI) |
|---|---|---|---|---|---|
| Excellent | 11.399 | 3.321 | 11.779 | 0.001 | |
| Good | 16.223 | 3.462 | 21.965 | <0.01 | |
| Hypertension | -0.335 | 0.271 | 1.527 | 0.271 | |
| Diabetes | 0.176 | 0.056 | 9.786 | 0.002 | 1.19 (1.07, 1.33) |
| COPD | -0.061 | 0.328 | 0.034 | 0.853 | |
| CHD | 0.378 | 0.308 | 1.510 | 0.219 | |

COPD: chronic obstructive pulmonary diseases; CHD: coronary heart disease; CI: confidence interval; OR: odds ratio; SE: standard error.

erative adverse events related to the circulatory system. In our study, the rate of patients with hypertension and/or CHD was also high. Blood pressure control is beneficial for reducing the occurrence of complications and reducing bleeding during the operation. The blood pressure in patients with hypertension needs to be carefully controlled. For such patients, surgeons should pay attention to the blood pressure to reduce central and critical damage. Perioperatively, it is easy to cause a micro thrombus due to the patient's highly coagulable state. Gandhi [10] surveyed >3,400 cases of joint replacement and found that the incidence of myocardial infarction during hospitalization is as high as 1.8%. Thus, doctors need to fully assess the patient's preoperative heart function to avoid adverse events.

Respiratory disease is another big threat. In this study, the rate of COPD was 15%. Previous reports have shown that patients with COPD had a relative risk of 2.7-4.7 for postoperative complications [7]. This kind of disease reduces lung compliance and may cause an anoxic condition. During the perioperative period, the incidence of adverse events caused by acute hypoxia was 4% [11]. Because of the subtle changes in the structure of the lung, the rate of pulmonary infection increased significantly. As a result of atypical symptoms, mixed infection of flora, and drug resistance, mortality was high. In the current study, 6 patients died of lung infection, which was also associated with this factor. Surgeons need to carefully maintain normal oxygen saturation of patients and avoid hypoxia caused by cardiopulmonary function changes during perioperative adjustments.

In addition to basic diseases, BMI is another factor that affects patients' prognoses. Some scholars believe that obese patients are more likely to have postoperative dislocation, prosthesis loosening, and other postoperative complications [12, 13]. However, other scholars think that there is no relationship between joint function and BMI [14]. According to the present study's results, the change in BMI was one of the main factors that affected patients' postoperative HHS. The HHS was lower in patients with a higher BMI, and there may be two reasons for this: 1. excess fat distribution increases the body load, and reduction of circulation function and joint pain lead to a poor daily life; 2. after joint replacement, obese patients are more likely to have articular cartilage and prosthesis wear, which may cause discomfort [8]. In addition, the thickening of body fat may cause a deeper intraoperative incision, leading to fat liquefaction and necrosis of the wound skin. This is a significant factor that affects the patients' prognoses. However, with the increasing obesity, diseases of the cardiovascular, endocrine, and motor systems will increase accordingly [15]. Consequently, weight control in the elderly needs to be studied in more detail.

Another important influence on prognosis is diabetes, which is associated with an increased BMI. Existing studies have shown that diabetes is an increasing risk factor for osteoporosis. The fracture rate is high in diabetic patients [16]. In this study, we found that diabetes had a negative effect on the reconstruction of joint function. With the progression of the disease, organs such as the vessels, kidney, and retina will gradually develop disorders, which may seriously affect the patient's self-care ability and life quality. Because of poor blood sugar control, changes in microcirculation may cause growth restriction in granulation tissue, which easily causes poor wound healing. As several systems are gradually affected, different complications will cause a high mortality. In the current study's follow-up process, three patients died of diabetic complications within 1 year postoperatively. Patients with diabetes have another hidden danger: joint infection [17]. In addition, the increase of microcirculation may enhance the risk of deep vein thrombosis formation with the progression of diabetes [18]. In light of these factors, patients with diabetes

need to regularly control their blood sugar, and more attention is needed in terms of perioperative monitoring and adjustments.

In this study, we also found that the ASA score was associated with the patients' joint function. The results showed that the high score group's joint function was worse than the low score group's joint function. A few reports in the literature confirm the same finding. The ASA score was evaluated according to the patients' health condition, life, and ability to work. Patients of levels I and II generally had a good condition. Those of levels III and IV had certain risks that surgeons needed to prepare for. A high score indicates that the patient's preoperative condition is generally poor with a low quality of life. Thus, their postoperative functional recovery can be predicted. The findings of postoperative functional recovery seemed to be related with the predictive ASA score.

In general, the uncemented artificial femoral head prosthesis for treating femoral neck fractures in aged patients was associated with good outcomes. We found that the patients' age, BMI, ASA score, and comorbidities are factors that will affect joint function postoperatively. However, there were still some shortcomings in this study. First, our study mainly focused on a short-term follow-up so it lacked long-term data to support our theory. Second, to evaluate the patients' postoperative joint function, we only used the HHS. Factors such as the patients' quality of life remain to be further evaluated. Finally, this was only a preliminary analysis of the factors related to patients' prognosis. The influence of various confounding factors needs to be eliminated by performing further stratified analyses.

## Conclusions

Uncemented femoral head replacement is widely used for femoral neck fractures in aged patients. Patients' age, BMI, ASA score, and comorbidities are factors that will affect joint function postoperatively. Patients with an older age, a high BMI, a high ASA score, and more comorbidities may have a poorer functional outcome. In those with hypertension, CHD, diabetes, and COPD, the main negative factor affecting the prognosis is diabetes. Thus, more attention is needed to provide better rehabilitation to patients who are old and obese with a higher ASA score and diabetes.

## Disclosure of conflict of interest

None.

**Address correspondence to:** Zhenan Zhu, Department of Orthopaedics, Shanghai Key Laboratory of Orthopedic Implants, Shanghai Ninth People's Hospital, School of Medicine, Shanghai Jiaotong University, 639 Zhizaoju Road, Shanghai 200011, China. Tel: +8621 6313 9920; Fax: +8621 6313 9920; E-mail: zhuzhenan2006@126.com

## References

[1] Ahn J, Man LX, Park S, Sodl JF and Esterhai JL. Systematic review of cemented and uncemented hemiarthroplasty outcomes for femoral neck fractures. Clin Orthop Relat Res 2008; 466: 2513-2518.

[2] Bell KR, Clement ND, Jenkins PJ and Keating JF. A comparison of the use of uncemented hydroxyapatite-coated bipolar and cemented femoral stems in the treatment of femoral neck fractures: a case-control study. Bone Joint J 2014; 96-B: 299-305.

[3] Bolognesi MP, Marchant MH Jr, Viens NA, Cook C, Pietrobon R and Vail TP. The impact of diabetes on perioperative patient outcomes after total hip and total knee arthroplasty in the United States. J Arthroplasty 2008; 23: 92-98.

[4] Singh JA and Lewallen DG. Medical comorbidity is associated with persistent index hip pain after total hip arthroplasty. Pain Med 2013; 14: 1222-1229.

[5] Stevens M, Paans N, Wagenmakers R, van Beveren J, van Raay JJ, van der Meer K, Stewart R, Bulstra SK, Reininga IH and van den Akker-Scheek I. The influence of overweight/obesity on patient-perceived physical functioning and health-related quality of life after primary total hip arthroplasty. Obes Surg 2012; 22: 523-529.

[6] Beswick AD, Wylde V, Gooberman-Hill R, Blom A and Dieppe P. What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients. BMJ Open 2012; 2: e000435.

[7] Hawker GA, Badley EM, Borkhoff CM, Croxford R, Davis AM, Dunn S, Gignac MA, Jaglal SB, Kreder HJ and Sale JE. Which patients are most likely to benefit from total joint arthroplasty? Arthritis Rheum 2013; 65: 1243-1252.

[8] Ng VY, Lustenberger D, Hoang K, Urchek R, Beal M, Calhoun JH and Glassman AH. Preo-

perative risk stratification and risk reduction for total joint reconstruction: AAOS exhibit selection. J Bone Joint Surg Am 2013; 95: e191-115.
[9] Parvizi J, Holiday AD, Ereth MH and Lewallen DG. The Frank Stinchfield Award. Sudden death during primary hip arthroplasty. Clin Orthop Relat Res 1999; 39-48.
[10] Gandhi R, Petruccelli D, Devereaux PJ, Adili A, Hubmann M and de Beer J. Incidence and timing of myocardial infarction after total joint arthroplasty. J Arthroplasty 2006; 21: 874-877.
[11] Austin L, Pulido L, Ropiak R, Porat M, Parvizi J and Rothman RH. Hypoxemia after total joint arthroplasty: a problem on the rise. J Arthroplasty 2008; 23: 1016-1021.
[12] Moran M, Walmsley P, Gray A and Brenkel IJ. Does body mass index affect the early outcome of primary total hip arthroplasty? J Arthroplasty 2005; 20: 866-869.
[13] Namba RS, Paxton L, Fithian DC and Stone ML. Obesity and perioperative morbidity in total hip and total knee arthroplasty patients. J Arthroplasty 2005; 20: 46-50.
[14] Stickles B, Phillips L, Brox WT, Owens B and Lanzer WL. Defining the relationship between obesity and total joint arthroplasty. Obes Res 2001; 9: 219-223.
[15] Powell KE and Blair SN. The public health burdens of sedentary living habits: theoretical but realistic estimates. Med Sci Sports Exerc 1994; 26: 851-856.
[16] Leidig-Bruckner G, Grobholz S, Bruckner T, Scheidt-Nave C, Nawroth P and Schneider JG. Prevalence and determinants of osteoporosis in patients with type 1 and type 2 diabetes mellitus. BMC Endocr Disord 2014; 14: 33.
[17] Jamsen E, Nevalainen P, Eskelinen A, Huotari K, Kalliovalkama J and Moilanen T. Obesity, diabetes, and preoperative hyperglycemia as predictors of periprosthetic joint infection: a single-center analysis of 7181 primary hip and knee replacements for osteoarthritis. J Bone Joint Surg Am 2012; 94: e101.
[18] Zhang J, Chen Z, Zheng J, Breusch SJ and Tian J. Risk factors for venous thromboembolism after total hip and total knee arthroplasty: a meta-analysis. Arch Orthop Trauma Surg 2015; 135: 759-72.