Additional File 2

Table S1. Characteristics of included studies

Author	Study Design	Sample Characteristics	Joint replaced	Timeframe: Pre-operative or post-operative	Recall time for falls	Number of falls	Measures	Results			Quality of Study
						Pre-operative studies					
Hill et al. (2016) *Australia*	Cross sectional	n=282 Age: 67.3 ±8.6 yrs Female n =155 (55%)	Hip (n=85) Knee (n=197) Total (n=282)	pre-operative = 2-4 weeks	12 months	116 (41%) had one fall or more in the past 12 months		*TKA Non-fallers*	*TKA Fallers*	*p-value*	Acceptable
							Falls Efficacy Scale: International 7-28 (7: no concern)	11.4 ± 3.8	13.5 ± 5.6	0.005	
							Activities- Specific Balance Confidence Scale 0-100 (0: least fearful)	71.2 ± 22.1	63.8 ± 20.6	0.051	
							WOMAC Function, VAS Scale 0-1700 (0: no difficulty with function)	671.7 ± 280.0	807.4 ± 282.00	0.020*	
							Self-perceived quality of life (SF-36 Mental) 0-100 (0: lowest quality)	54.9 ± 9.7	50.6 ± 13.1	0.030*	
							Pain (Pain Catastrophizing Scale) 0-52 (0:least catastrophizing)	11.1 ± 9.5	14.4 ± 11.5	0.021**	
							Cardiac Depression Scale (CDS) 26 – 182 (26: least depressive mood)	S68.2 ± 21.2	79.5 ± 23.9	0.007*	

* One-way ANOVA post hoc: significant difference between multiple fallers and other groups
** One-way ANOVA post hoc: significant difference between all three groups

Not significant: TKA patients- WOMAC pain/ stiffness/ total; SF-36 Physical Component Score; Tampa Scale for Kinesiophobia; IPEQ Incidental Activity; IPEQ planned activity / total activity were not significantly different between non-fallers and multiple fallers.

Not significant: THA patients - WOMAC pain/ stiffness/ function/ total; Pain Catastrophizing Scale; SF-36 Physical Component score/ Mental Component Score; Tampa Scale for Kinesiophobia; Cardiac Depression Scale; IPEQ incidental/ planned/ total

Study	Design	Sample	Joint	Pre-operative time	Follow-up	Fall outcome	Results	Quality
Mitchell et al. (2007) *United Kingdom*	Cross Sectional	n = 199 Age: 72 (95% CI: 71.6, 72.7) yrs Female 111 (55.6%)	Hip (n=84) Knee (n=115)	pre-operative time points not specified	4 weeks	75 (39%) of pre-op patients fell at least once		Poor

Mitchell et al. results:

	Non fallers	Fallers	p-value
WOMAC Pain* 0 – 100, 0 least pain	45	33	0.0012
WOMAC Function* 0 – 100, 0 no difficulty with function	41	33	0.0001
Self-perceived quality of life -36 *	28	20	<0.05
Physical Functioning	33	25	<0.05
Bodily Pain	17	7	<0.05
Role Physical	60	52	<0.05
General Health	48	40	<0.05
Vitality	56	36	<0.05
Role Emotional			
Timed Up and Go – mean (95% CI)	16 (14.9, 17.0)	19.8 (16.8, 22.8)	0.02
Hypnotic/Antidepressant Medication – n (95% CI)	8/119 (7)	13/75 (17)	0.02
Number of Comorbid Conditions – mean (95% CI)	1.9 (1.6, 2.1)	2.6 (2.2, 3.0)	0.0025
Self-Reported Depression – n (95% CI)	14/115 (12)	17/69 (25)	0.0025
Number of Geriatric Problems – mean (95% CI)	1.2 (0.9, 1.4)	1.8 (1.5, 2.1)	0.0016
Self-Reported Memory Problem – n (95% CI)	11/114 (10)	17/72 (24)	0.010
Self-Reported Balance Problem – n (95% CI)	37/114 (33)	42/72 (58)	0.0005

Not significant: WOMAC stiffness, SF-Social Functioning, SF-Role Emotional (p>0.05), age, sex, joint being replaced, osteoporosis at any site, use of parathyroid hormone, use of vitamin D, BMI, and number of prescription medications were not statistically different between non-fallers and fallers.

	Adjusted OR (for sex and gender) for factors associated with falling	p-value
Number of comorbid conditions > 2	2.2 (1.03, 4.8)	<0.05
Self-reported balance problem	2.5 (1.2, 5.1)	<0.05

Not significant: Self reported depression, Hypnotic/antidepressant medication, more than one geriatric problem, and self-reported memory problem were factors that were not significantly associated with falling.

Study	Design	Sample	Joint	Pre-operative time	Follow-up	Fall outcome	Results	Quality
Pozzi et al (2015) USA	Cross Sectional	n=31 Age: 65 ± 8 yrs Female 31 (100%)	Hip (n=31)	Pre-operative = 2 weeks	6 months	7 (22.5%) of pre-op patients reported at least one fall within 6 months of survey		Poor

Pozzi et al. results:

	Non-fallers (n=24)	Fallers (n=7)	t-test	Correlation with fall (r, p-value)
Age	63 ± 8	71 ± 6	0.01	0.40, 0.03
Timed up and go (s)	10.9 ± 3.43	17.63 ± 11.13	>0.01	0.45, 0.01
Stair climbing (s)	22.64 ± 9.07	41.4 ± 20.4	>0.01	0.54, >0.01
6 minute walk test (m)	399.16 ±86.19	264.36 ±145.85	>0.01	-0.5, >0.01

						Total hip ROM, degrees	156.08 ±26.94	135.85 ±13.45	0.03	-0.33, 0.06	
						Knee extension on surgical side of hip, Nm/Kg	2.15 ± 1.13	1.33 ± 0.63	0.04	-0.32, 0.08	
						Knee extension on non-surgical side of hip, Nm/Kg	1.04 ± 2.19	2.08 ± 1.24	0.04	-0.31, 0.08	

Not significant: BMI; Hip Harris Score; Hip Outcome Score; low back pain on a 1-10 scale; hip pain on 1-10 scale for both surgical and non-surgical side; knee pain on 1-10 scale on surgical and non-surgical side; knee abductor strength on surgical and non-surgical side; are all not significantly different between non-fallers and fallers.

Tsonga et al (2015) *Greece*	Cross Sectional	n=68 Age: 73 ±5.8yrs Female 57 (83.8%)	Knee (n=68)	Pre-operative = 1 month	12 months	43 (63.2%) had one or more falls in the past 12 months		**Mean ± SD**				Acceptable

SF-36 Physical — 34.5 ± 6.99
SF-36 Mental — 36.36 ± 9.83
WOMAC (VAS Scale)
  Total — 822.79 ± 317.31
  Pain — 226.10 ± 85.24
  Stiffness — 56.62 ± 43.54
  Physical function — 540.07 ± 255.18
Timed Up and Go Performance Test (seconds) — 13.05 ± 4.13

Not significant: Gender; age; BMI; presence of pain elsewhere in the body; number chronic diseases; having a social environment; previous arthroplasty; SF-36 physical & mental component scores; WOMAC pain/ stiffness/ physical function; Timed Up and Go were not significantly different between non-fallers and fallers

Pre and post-operative studies

Levinger et al. (2011) *Australia*	Prospective Cohort	n=62 Age: 66 ±7 yrs Female n =30 (48%)	Knee (n=35) Non-Surgical Controls (n=27)	pre-operative time not specified post-operative = 4 months	12 months	17 (48%) of pre-op TKA patients fell 8 (30%) of non-surgical controls fell *Timeframe not reported for pre-op patients **Post-op prevalence of falls not measured		**Pre-operative**	**Post-operative**	**Non-surgical control**	Acceptable

FES-I 7-28 (7: no concern) — 11.4 ± 3.0 *[+] | 9.7 ± 2.9* | 7.6 ± 1.2
WOMAC Pain - VAS (range 0-500, 500 worst) — 192.5 ± 106.0 [+] | 171.5 ± 278.2 | -
WOMAC Stiffness - VAS (range 0-200, 200 worst) — 95.4 ± 46.7 [+] | 48.6 ± 37.3 | -
WOMAC Function - VAS (0-1,700) — 609.0 ± 325.9 [+] | 278.6 ± 236.0 | -
WOMAC Total - VAS (0-2,400) — 896.9 ± 430.4 [+] | 498.7 ±498.5 | -
Assessment of Quality of Life — 0.8 ± 0.0 [+] | 0.7 ± 0.1* | 0.8 ± 0.1
Incidental and Planned Activity Questionnaire: Incidental — 38.5 ± 19.8*[+] | 8.3 ± 14.5* | 19.5 ± 13.9
Incidental and Planned Activity Questionnaire: Total — 44.3 ± 20.6 *[+] | 12.1 ± 16.1 | 25.9 ± 16.3

Not significant : IPAQ planned was not significantly different between control and post-operative group.
* Significantly different to control
+Significantly different to post-surgery

| Riddle et al. (2016)

USA | Retrospective Cohort | Cases: n=413

Age: 63.9 ±6.8 yrs

Female: 251 (60.7%)

Controls: n=4,200

Age: 60.8 ±9.2 yrs

Female: 2,446 (58.2%)

Controls were OA patients and individuals at risk of OA (54% had no OA and 49.1% had grade 2 or more) that did not undergo TKA during the study period | Knee arthroplasty patients (n=413) | pre-operative = 4 years post-operative = 4 years | 12 months | 8-23% for men, and 15-23% for women fell at least once in the past year | | | Acceptable |
|---|---|---|---|---|---|---|---|---|---|

							Non-TKA (OR, 95% CI)	***TKA (OR, 95% CI)***	
							1 Fall (reference group: no falls)		
							Age 1.00, (0.99,1.01)	1.02 (1.01, 1.03)*	
							Male Sex 0.60 (0.49, 0.74)*	0.83 (0.67, 1.02)	
							No Narcotic Use 0.63 (0.41, 0.97)*	0.41 (0.33, 0.50)	
							No Prior Falls 0.74 (0.47, 1.15)*	0.78 (0.55, 1.20)*	
							Not significant (OR, 95% CI) PASE score; depressive symptoms; repeated chair stand; no comorbidity; no knee replacement	PASE score; depressive symptoms; repeated chair stand; no comorbidity; no knee replacement	
							2+ Falls (reference group: no falls)		
							Age 0.98 (0.97, 0.99)*	0.99 (0.98, 1.01)*	
							Depressive symptoms 1.05 (1.04, 1.07)*	1.04 (1.03, 1.05)*	
							No comorbidity 0.77 (0.60, 0.97)*	0.80 (0.66, 1.08)	
							No narcotic use 0.53 (0.34, 0.82)*	0.89 (0.55, 1.44)	
							No prior falls 0.16 (0.13, 0.21)*	0.14 (0.10, 0.18)*	
							Not significant (OR, 95% CI) Male sex; PASE score; repeated chair stand; no knee replacement	Male sex; PASE score; repeated chair stand; no knee replacement	

Study	Design	Sample	Joint	Follow-up timing	Fall def.	Fallers	Results				Quality
Swinkles et al. (2009) *UK*	Prospective Cohort	n=99 Age: 73.4 ± 4.9 yrs Female: 63(64%)	Knee (n=99)	pre-operative = 3 months post-operative =12 months	1 month	Pre-op: 24 (24%) fell Post-op: 11 (13%) fell		*3 Months Pre-Op*	*3 Months Post-Op*	*6 Months Post-Op* *12 Months Post-Op*	High

For Swinkles et al. (2009):

	3 Months Pre-Op	*3 Months Post-Op*	*6 Months Post-Op*	*12 Months Post-Op*
ABC-UK (0-100, 100 Best)				
Fallers	53.1±26.4	64.6±18.7	66.0±23.2	61.2±30.4
Non-Fallers	64.4±24.3	67.6±22.8	71.2±25.8	76.7±22.7

	Pre- Operative Fallers (n=24)	*Pre-Operative Non-Fallers (n=75)*
ABC – UK (0-100, 100 best)	53.1 ± 26.4	64.4 ±24.3
Geriatric Depression Scale (0-15, 15 worst)	5.4 ± 2.6	3.4 ± 2.5
WOMAC Pain (Likert) (0-20, 20 worst)	11.7 ± 2.7	10.4 ± 3.3
WOMAC Stiffness (Likert) (0-8, 8 worst)	5.4 ± 1.2	4.8 ± 1.6
WOMAC Function (Likert) (0-68, 68 worst)	42.7 ± 9.4	35.9 ± 11.4
WOMAC Total (Likert) (0-96, 96 worst)	59.5 ± 11.8	51.0 ± 15.5
Patients reporting falling 4 months prior to entry onto waitlist for TKA	12/23	4/75

Not significant:(adjusted OR and 95% CI for pre-operative and post-operative patients): female gender; age; number of comorbid conditions; number of baseline medications including cardiovascular medications, anti-depressants; self-reported eye problems; self-reported hearing problems.

Study	Design	Sample	Joint	Follow-up timing	Fall def.	Fallers	Quality
Tsonga et al (2016) *Greece*	Prospective Cohort	n=68 Age: 73 ± 5.28 yrs Female: 57 (83.8%)	Knee (n=68)	pre-operative = 2 weeks post-operative = 1-12 months	1 month	Pre-op: 43 (63%) fell Post-op: 15 (22%) fell	Acceptable

For Tsonga et al (2016):

	Pre-operative	*1 year Post-operative*
Fear of Falling (Yes)	56 (82.4%)	30 44.1%
Fear of Falling –Activities Specific Balance Confidence Scale (0-100, 0 least confidence), mean ± SD	63.76 ± 20.14	81.49 ± 16.24

	Fallers at 1 year post-op	*Non-Fallers at 1 year post-op*
Fear of Falling –Activities Specific Balance Confidence	79.50 ± 13.99	82.05 ± 16.90
Fearful of Falling (Yes/No)	11 (73.3%)	19 (35.8%)
History of Falls (Yes/No)	12 (30.2%)	30 (69.8%)

Not significant: Age; gender; BMI; pain elsewhere in the body; chronic diseases ; complications during surgery; social environment; presence of social environment; previous arthroplasty surgery; SF-36 Physical & Mental component scores; WOMAC pain/ stiffness/ physical function; PASE physical activity questionnaire; Timed Up and Go, and Berg Balance scale were not significantly different between fallers and non-fallers at 1 year post-op.

							Results	Quality
							O.R, 95%CI (multiple logistic regression of falling status at 1 year post-op) stepwise method Age 1.13, (0.98, 1.30) Fear of Falling 11.90 (2.20, 64.20) *Falling Status 7.23 (1.28, 41.01)*	
Post-operative studies								
Ikutomo et al (2015) *Japan*	Cross Sectional	n=214 Age: 66 ±8.7 yrs Female 203 (95%)	Hip (n=214)	post-operative= 1 year	12 months	77 (36%) of post-op patients fell	***Non-Fallers Fallers p-value*** Age (yrs) 86.3 ± 8.2 64.7 ± 8.7 0.004 Height (cm) 153 ± 6.2 154.8 ± 5.9 0.037 Medication, n (%) 63 (81.8) 69 (50.4) <0.001 Less than one comorbid medical condition, n (%) 30 (39) 73 (53.3) 0.044 Post-operative duration, years (interquartile range) 4 (2-7) 5 (2-8) 0.023 Total Oxford Hip Score 16 (14-19) 14 (12-17) <0.001 Use of a walking aid, n (%) 27 (35.1) 25 (18.2) 0.006 Walking capacity –"can you walk for more than 60 minutes without stopping?" n (%) 32 (41.6) 88 (64.2) 0.001 **Not significant:** Sex; body weight; BMI; THA side were not different between non-fallers and fallers. ***Adjusted OR (95%CI)** (for sex and gender) for factors associated with falling* *p*-value Medications 4.09 (1.90, 8.80) <0.001 Post Operative Duration, years (IQR) 0.89 (0.81, 0.98) 0.014	Poor
Matsumoto (2012) *Japan*	Prospective Cohort	n=74 Age: 75 ± 6 yrs Female: 57 (88%)	Knee (n=70)	post-operative =6-11 months	1 month, for 6 months	23 (32.9%) fell once or more during a 6-month observation period	***Fallers Non-Fallers p-value*** Modified Falls Efficacy Scale (M-FES) 122.2 ± 27.1 123.3 ± 23.3 0.874 Post operative flexion 10.2 ± 16.1 119.5 ± 14.1 0.016 Post operative flexion and extension 100.6 ± 18.4 109.7 ± 15.9 0.037 ROM of the ankle (°) – plantar flexion 55.2 ± 6.1 59.1 ± 6.1 0.014 **Not significant:** Age; gender; BMI; TKA side; diagnosis of OA or RA; mean time since surgery; prior hip surgery; total number of prescribed medications; hearing problems; eye problems; cardiac disease; diabetes; hypertension; ambulation; pre-operative knee flexion; pre-operative knee extension; pre-operative range of flexion and extension; post operative extension; ankle dorsiflexion; joint instability; knee extensor strength; hallux valgus; limited ankle mobility; kyphosis; one-leg stand; 10 minute walking speed; step length; JKOM total score; pain; limitation of activity; restriction of participation; and Geriatric Depression Scale; were not statistically different between fallers and non-fallers.	High

								OR (95% CI)	p-value
							Knee flexion (post op) (10 degree groups, 80-140)	0.277 (0.088-0.869)	0.028
							Knee flexion and extension (post op (10 degree groups, 60-135)	2.308 (0.847-6.289)	0.102
							Ankle plantar flexion (5 degree groups, 40-70)	0.594 (0.374-0.945)	0.028

Soison et al (2014) *Thailand*	Cross Sectional	n=54 Age: 67 ±8 yrs Female 46 (85%)	Knee (n=54)	post–operative= 7-73 months	12 months	23 (42%) of post-op patients fell	**Non-Fallers** / **Fallers** / **p-value** table below		Poor

Soison et al (2014) row detail:

	Non-Fallers	Fallers	p-value
Height (cm)	156.06 ± 7.29	154.26 ± 4.22	<0.005
Limited Knee Joint Motion (case)	2	7	<0.05

Not significant: Age, weight, BMI, time after surgery, VAS, WOMAC pain, stiffness, function, total, satisfaction score (maximum score 10), vision problems

	Coefficient of association between risk factor and falls	Standard Error	p value
WOMAC Pain	0.048	0.021	<0.05
WOMAC Stiffness	0.141	0.049	<0.025
Limit Knee Joint Motion (flexion <120° and/or joint was not able to fully extend 0°)	0.594	0.227	<0.025

Not significant: Sex; vision problems; BMI; VAS; WOMAC function/ total score.

Smith et al (2014) *United Kingdom*	Retrospective Cohort	n=269 Age: 67 ± 9 yrs Female 112 (41.6%)	Hip (n=104) Knee (n=165)	post-operative = 12-72 months	12 months	26 (25%) of post-op THA patients fell at least once 43 (26.1%) of post-op TKA patients fell at least once	Falls data table below		Acceptable

Smith et al (2014) row detail:

	Falls in THA patients	Falls in TKA patients
Bisphosphonate use (OR, 95% CI: p value)	1.28 (1.03, 1.58) 0.02	1.23 (1.03, 1.58) 0.03
Knee OA in the past (OR, 95% CI: p value)	1.51 (1.06, 2.04) 0.02	-
Not significant:	Age; gender; marital status; employment; diagnosis of hip OA; race	Age; gender; marital status; employment; previous hip arthroplasty; diagnosis of hip OA; diagnosis of knee OA; race