

Actigraphy to Measure Physical Activity in the Intensive Care Unit: A Systematic Review

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APPENDICES

Appendix A. Search Strategy

Database	Search Terms	Results
PubMed	("acute care"[tw] OR "acute disease"[MeSH] OR "anesthesia department, hospital"[MeSH] OR "anesthesia recovery period"[MeSH] OR "anesthesia"[MeSH:noexp] OR "anesthetic recovery"[tw] OR "assisted circulation"[tw] OR "burns"[MeSH] OR cardiac surgical procedure*[tw] OR "cardiopulmonary bypass"[tw] OR cardiovascular surgical procedure*[tw] OR "controlled respiration"[tw] OR "controlled ventilation"[tw] OR "craniectomies"[tw] OR "craniectomy"[tw] OR "critical care"[MeSH] OR "critical care"[tw] OR "critical illness"[MeSH] OR "critical illness"[tw] OR "critically ill"[tw] OR "ecmo"[tw] OR "extracorporeal circulation"[tw] OR "extracorporeal membrane oxygenation"[tw] OR "general surgery"[MeSH] OR heart-assist device*[tw] OR "intensive care units"[MeSH] OR "intensive care"[tw] OR neurosurgical procedure*[tw] OR organ transplant*[tw] OR "postoperative care"[MeSH] OR "postoperative period"[MeSH] OR "pulmonary surgical procedure"[tw] OR "recovery room"[MeSH] OR "respiration, artificial"[MeSH] OR "respiratory weaning"[tw] OR "specialties, surgical"[MeSH:noexp] OR "surgery"[subheading] OR "surgical decompression"[tw] OR "surgical procedures, operative"[MeSH] OR "surgical"[tw] OR thoracic surgical procedure*[tw] OR vascular surgical procedure*[tw] OR "ventilator weaning"[tw] OR acute condition*[tw] OR acute disease*[tw] OR acute disorder*[tw] OR anaesthes*[tw] OR anaesthesia* [tw] OR anesthes*[tw] OR anesthesia* [tw] OR artificial respiration*[tw] OR artificial ventilation*[tw] OR burn*[tw] OR coronary care unit*[tw] OR esophagectom*[tw] OR hepatectom*[tw] OR icu*[tw] OR mechanical ventilation*[tw] OR pancreatectom*[tw] OR pancreaticoduodenectom*[tw] OR pancreatocoejunostom*[tw] OR postoperative*[tw] OR postsurger*[tw] OR recovery room*[tw] OR respiratory therap*[tw] OR sternotom*[tw] OR surger*[tw] OR thoracotom*[tw] OR ventilat*[tw]) AND ("actigraphy"[MeSH] OR "accelerometry"[MeSH] OR acceleromet*[tw] OR actimet*[tw] OR actig*[tw] OR actomet*[tw])	912
Embase	('acute care':ti,ab,de or 'acute condition':ti,ab,de or 'acute conditions':ti,ab,de or 'acute disease':ti,ab,de or 'acute diseased':ti,ab,de or 'acute diseases':ti,ab,de or 'acute disorder':ti,ab,de or 'acute disorders':ti,ab,de or anaesthes*:ti,ab,de or anesthes*:ti,ab,de or 'anesthesia'/de or 'anesthetic recovery'/exp or 'artificial respiration':ti,ab,de or 'artificial respirations':ti,ab,de or 'artificial ventilation'/exp or 'artificial ventilation':ti,ab,de or 'artificial ventilations':ti,ab,de or 'assisted circulation':ti,ab,de or burn*:ti,ab,de or 'burn'/exp or 'cardiac surgical procedure':ti,ab,de or 'cardiac surgical procedures':ti,ab,de or 'cardiopulmonary bypass':ti,ab,de or 'cardiovascular surgical procedure':ti,ab,de or 'cardiovascular surgical procedures':ti,ab,de or 'controlled respiration':ti,ab,de or 'controlled ventilation':ti,ab,de or 'coronary care unit':ti,ab,de or 'coronary care units':ti,ab,de or 'craniectomies':ti,ab,de or 'craniectomy':ti,ab,de or 'critical care':ti,ab,de or 'critical illness'/exp or 'critical illness':ti,ab,de or 'critically ill':ti,ab,de or 'ecmo':ti,ab,de or esophagectom*:ti,ab,de or 'extracorporeal circulation':ti,ab,de or 'extracorporeal membrane oxygenation':ti,ab,de or 'general surgery'/exp or 'heart-assist device':ti,ab,de or 'heart-assist devices':ti,ab,de or hepatectom*:ti,ab,de or icu*:ti,ab,de or 'intensive care unit'/exp or 'intensive care':ti,ab,de or 'mechanical ventilation':ti,ab,de or 'mechanical ventilations':ti,ab,de or 'neurosurgical procedure':ti,ab,de or 'neurosurgical procedures':ti,ab,de or 'organ transplant':ti,ab,de or 'organ transplantation':ti,ab,de or 'organ transplantations':ti,ab,de or 'organ transplants':ti,ab,de or pancreatectom*:ti,ab,de or pancreaticoduodenectom*:ti,ab,de or pancreatocoejunostom*:ti,ab,de or 'postoperative care'/exp or 'postoperative period'/exp or postoperative*:ti,ab,de or postsurger*:ti,ab,de or 'pulmonary surgical procedure':ti,ab,de or 'recovery room'/exp or 'recovery room':ti,ab,de or 'recovery rooms':ti,ab,de or 'respiratory therapeutic':ti,ab,de or 'respiratory therapeutics':ti,ab,de or 'respiratory therapies':ti,ab,de or 'respiratory therapy':ti,ab,de or 'respiratory weaning':ti,ab,de or sternotom*:ti,ab,de or surger*:ti,ab,de or 'surgery'/de or 'surgical decompression':ti,ab,de or 'surgical':ti,ab,de or 'thoracic surgical procedure':ti,ab,de or 'thoracic surgical procedures':ti,ab,de or thoracotom*:ti,ab,de or 'vascular surgical procedure':ti,ab,de or 'vascular surgical procedures':ti,ab,de or ventilat*:ti,ab,de or 'ventilator weaning':ti,ab,de) and ('actimetry'/exp or 'accelerometry'/exp or acceleromet*:ti,ab,de or actimet*:ti,ab,de or actig*:ti,ab,de or actomet*:ti,ab,de)	1,483

CINAHL

(MH("acute care" OR "acute disease" OR "anesthesia" OR "anesthesia recovery" OR "Respiration, Artificial+" OR "burns+" OR "burn units" OR "critical care+" OR "critical illness" OR "intensive care units+" OR "surgery, operative+" OR "specialties, surgical" OR "postoperative period" OR "postoperative care+") OR (TX("acute care" OR "acute condition" OR "acute conditions" OR "acute disease" OR "acute diseases" OR "acute diseased" OR "acute disorder" OR "acute disorders" OR anesthes* OR anaesthes* OR "anesthetic recovery" OR "artificial respiration" OR "artificial respirations" OR "artificial ventilation" OR "artificial ventilations" OR "assisted circulation" OR burn* OR "cardiac surgical procedure" OR "cardiac surgical procedures" OR "cardiopulmonary bypass" OR "cardiovascular surgical procedure" OR "cardiovascular surgical procedures" OR "controlled respiration" OR "controlled ventilation" OR "coronary care unit" OR "coronary care units" OR craniectomy OR craniectomies OR "critical care" OR "critical illness" OR "critically ill" OR ecmo OR esophagectom* OR "extracorporeal circulation" OR "extracorporeal membrane oxygenation" OR "heart-assist device" OR "heart-assist devices" OR hepatectom* OR ICU* OR "intensive care" OR "mechanical ventilation" OR "mechanical ventilations" OR "neurosurgical procedure" OR "neurosurgical procedures" OR "organ transplant" OR "organ transplantation" OR "organ transplantations" OR "organ transplants" OR pancreatectom* OR pancreaticoduodenectom* OR pancreatocoejunostom* OR postoperative* OR postsurger* OR "pulmonary surgical procedure" OR "pulmonary surgical procedures" OR "recovery room" OR "recovery rooms" OR "respiratory therapy" OR "respiratory therapies" OR "respiratory therapeutic" OR "respiratory therapeutics" OR "respiratory weaning" OR sternotom* OR surgical OR surger* OR "surgical decompression" OR "thoracic surgical procedure" OR "thoracic surgical procedures" OR thoracotom* OR "vascular surgical procedure" OR "vascular surgical procedures" OR ventilat* OR "ventilator weaning")) AND ((MH "accelerometry+" OR (TX(acceleromet* OR actimet* OR actig* OR actomet*))))

2,192

#1 "acute care":ti,ab,kw
 #2 "acute condition*":ti,ab,kw
 #3 "acute disease*":ti,ab,kw
 #4 MeSH descriptor: [Acute Disease] explode all trees
 #5 "acute disorder*":ti,ab,kw
 #6 anaesthes*:ti,ab,kw
 #7 anesthes*:ti,ab,kw
 #8 MeSH descriptor: [Anesthesia Recovery Period] explode all trees
 #9 MeSH descriptor: [Anesthesia] this term only
 #10 "artificial respiration*":ti,ab,kw
 #11 MeSH descriptor: [Respiration, Artificial] explode all trees
 #12 "artificial ventilation*":ti,ab,kw
 #13 "assisted circulation":ti,ab,kw
 #14 burn*:ti,ab,kw
 #15 MeSH descriptor: [Burns] explode all trees
 #16 "cardiac surgical procedure*":ti,ab,kw
 #17 "cardiopulmonary bypass":ti,ab,kw
 #18 "cardiovascular surgical procedure*":ti,ab,kw
 #19 "controlled respiration":ti,ab,kw
 #20 "controlled ventilation":ti,ab,kw
 #21 "coronary care unit*":ti,ab,kw
 #22 craniectomy:ti,ab,kw
 #23 MeSH descriptor: [Critical Care] explode all trees
 #24 "critical care":ti,ab,kw
 #25 MeSH descriptor: [Critical Illness] explode all trees
 #26 "critical illness":ti,ab,kw
 #27 "critically ill":ti,ab,kw
 #28 ecmo:ti,ab,kw
 #29 esophagectom*:ti,ab,kw
 #30 "extracorporeal circulation":ti,ab,kw
 #31 "extracorporeal membrane oxygenation":ti,ab,kw
 #32 MeSH descriptor: [General Surgery]
 #33 "heart-assist device*":ti,ab,kw
 #34 hepatectom*:ti,ab,kw
 #35 icu*:ti,ab,kw
 #36 MeSH descriptor: [Intensive Care Units] explode all trees
 #37 "intensive care":ti,ab,kw
 #38 "mechanical ventilation*":ti,ab,kw
 #39 "neurosurgical procedure*":ti,ab,kw
 #40 "organ transplant*":ti,ab,kw
 #41 pancreatectom*:ti,ab,kw
 #42 pancreaticoduodenectom*:ti,ab,kw
 #43 pancreaticejunostom*:ti,ab,kw
 #44 MeSH descriptor: [Postoperative Care] explode all trees
 #45 MeSH descriptor: [Postoperative Period] explode all trees
 #46 postoperative*:ti,ab,kw
 #47 postsurger*:ti,ab,kw
 #48 "pulmonary surgical procedure":ti,ab,kw
 #49 MeSH descriptor: [Recovery Room] explode all trees
 #50 "recovery room*":ti,ab,kw
 #51 "respiratory therap*":ti,ab,kw
 #52 "respiratory weaning":ti,ab,kw
 #53 sternotom*:ti,ab,kw
 #54 surger*:ti,ab,kw
 #55 MeSH descriptor: [Anesthesia Department, Hospital] explode all trees
 #56 MeSH descriptor: [Specialties, Surgical] this term only
 #57 MeSH descriptor: [Surgical Procedures, Operative] explode all trees
 #58 "surgical decompression":ti,ab,kw
 #59 surgical:ti,ab,kw
 #60 "thoracic surgical procedure*":ti,ab,kw
 #61 thoracotom*:ti,ab,kw
 #62 "vascular surgical procedure*":ti,ab,kw

	#63	ventilat*:ti,ab,kw
	#64	"ventilator weaning":ti,ab,kw
	#65	MeSH descriptor: [Actigraphy] explode all trees
	#66	MeSH descriptor: [Accelerometry] explode all trees
	#67	acceleromet*:ti,ab,kw
	#68	actimet*:ti,ab,kw
	#69	actig*:ti,ab,kw
	#70	actomet*:ti,ab,kw
	#71	"anesthetic recovery":ti,ab,kw
	#72	craniectomies:ti,ab,kw
	#73	anesthesia*:ti,ab,kw
	#74	anaesthesia*:ti,ab,kw
	#75	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 or #65 or #66 or #67 or #68 or #69 or #70 or #71 or #72 or #73 or #74
Proquest		(all("acute care" OR "acute condition" OR "acute conditions" OR "acute disease" OR "acute diseases" OR "acute diseased" OR "acute disorder" OR "acute disorders" OR anesthes* OR anaesthes* OR "anesthetic recovery" OR "artificial respiration" OR "artificial respirations" OR "artificial ventilation" OR "artificial ventilations" OR "assisted circulation" OR burn* OR "cardiac surgical procedure" OR "cardiac surgical procedures" OR "cardiopulmonary bypass" OR "cardiovascular surgical procedure" OR "cardiovascular surgical procedures" OR "controlled respiration" OR "controlled ventilation" OR "coronary care unit" OR "coronary care units" OR craniectomy OR craniectomies OR "critical care" OR "critical illness" OR "critically ill" OR ecmo OR esophagectom* OR "extracorporeal circulation" OR "extracorporeal membrane oxygenation" OR "heart-assist device" OR "heart-assist devices" OR hepatectom* OR ICU* OR "intensive care" OR "mechanical ventilation" OR "mechanical ventilations" OR "neurosurgical procedure" OR "neurosurgical procedures" OR "organ transplant" OR "organ transplantation" OR "organ transplantations" OR "organ transplants" OR pancreatectom* OR pancreaticoduodenectom* OR pancreaticojejunostom* OR postoperative* OR postsurger* OR "pulmonary surgical procedure" OR "pulmonary surgical procedures" OR "recovery room" OR "recovery rooms" OR "respiratory therapy" OR "respiratory therapies" OR "respiratory therapeutic" OR "respiratory therapeutics" OR "respiratory weaning" OR sternotom* OR surgical OR surger* OR "surgical decompression" OR "thoracic surgical procedure" OR "thoracic surgical procedures" OR thoracotom* OR "vascular surgical procedure" OR "vascular surgical procedures" OR ventilat* OR "ventilator weaning") OR SU("Critical care" OR "intensive care" OR "ventilation" OR "surgery" OR "anesthesia" OR "burns" OR "postoperative period")) AND all(accelerometer OR accelerometry OR actimet* OR actigraph* OR actomet*)

Appendix B. Risk of Bias Assessment for Randomized Controlled Trials (Cochrane Method)

Study	Random sequence (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Incomplete outcome data addressed (attrition bias)	Selective reporting	Other potential threats
Ono et al. (16)	○	○	●	○	○	○
Taguchi et al. (15)	◐	◐	●	○	○	○

● = High Risk of Bias

◐ = Unclear Risk of Bias

○ = Low Risk of Bias

Appendix C. Risk of Bias Assessment for Observational Studies (Newcastle Ottawa Scale)

Study	Selection			Comparability		Outcome		
	Representativeness of exposed cohort ^a	Selection of non-exposed cohort ^b	Ascertainment of exposure(s) ^b	Demonstration that mobility disorders/problems were not present at start ^c	Comparability of cohorts ^c	Assessment of outcome ^d	Was follow-up long enough for outcome to occur? ^e	Adequacy of follow-up ^f
Duclos et al. (14)	○					●	○	○
Grap et al (13)	○					●	○	○
Grap et al. (4)	○					●	○	○
Grap et al. (12)	○					●	○	○
Mistraletti et al. (8)	○					●	○	○
Osse et al. (9)	○					●	○	○
Osse et al. (10)	○					●	○	○
Paul et al. (6)	○					●	○	○
Redeker et al. (1)	○					●	○	○
Redeker et al. (2)	●					●	○	○
Whetstone Foster et al. (5)	●					●	●	○
Winkelman et al. (7)	○					●	●	○
Winkelman et al. (3)	●					●	○	○
Winkelman (11)	●					●	○	○

● = High Risk of Bias

○ = Unclear Risk of Bias

○ = Low Risk of Bias

^a High Risk if not consecutively screened, chosen based on specific criteria

^b Only applicable for studies with a pre-defined exposure

^c Only applicable for Cohort studies

^d High Risk if not compared to other scale (i.e., PSG)

^e High Risk if individual study period <24 hours, Low Risk if >24 hours

^f High Risk if >10% lost to follow up, Low Risk if <10% lost to follow up

Appendix D. Activity Parameters Using Actigraph Devices

Study Name	Device Placement	Device; Epoch Setting	Actigraphy Recording Duration [*]	Total Activity Time [†]	Total Activity Count (movements per epoch) [‡]			Immobility (zero-activity minutes) [‡]		Restlessness Index [‡]	
					Daytime	Nighttime	Mean	Daytime	Nighttime	Daytime	Nighttime
Redeker et al. ¹	Wrist	ML 60s	0-7 days	–	–	–	1455 (520) [§]	–	–	–	–
Redeker et al. ²	Wrist	MML 60s	0-7 days	–	–	–	1356 (302) [§]	–	–	–	–
Winkelman et al. ³	Wrist	ML 60s	24 hours	64	–	–	–	–	–	–	–
Grap et al. ⁴	Wrist, Ankle	AW16 15s	2 hours	–	418 (592) ^{, ¶} 147 (387) ^{, #}	–	–	–	–	–	–
Whetstone Foster et al. ⁵	Wrist	AW –	24 hours	–	–	–	18 (37) ^{**} 13 (29) ^{††} 9 (5) ^{‡‡}	–	–	–	–
Paul et al. ⁶	Wrist	MMB 60s	–	–	–	–	–	–	–	–	–
Winkelman et al. ⁷	Wrist	–	8 hours	–	–	–	–	–	–	–	–
Taguchi et al. ¹⁵	–	AC-210 –	5 days	–	–	–	–	–	–	–	–
Mistraletti et al. ⁸	Wrist	BTP 15s, 120s	2-6 days	–	33 [20, 49]	9 [4, 14]	–	–	–	–	–
Osse et al. ⁹	Wrist	AW 60s	24 hours	–	25 [3, 200] ^{¶¶} 32 [9, 92] ^{##}	2 [0, 80] ^{¶¶} 5 [0, 47] ^{##}	–	732 [50, 925] ^{¶¶} 632 [239, 836] ^{##}	395 [22, 420] ^{¶¶} 371 [22, 420] ^{##}	53 [11, 125] ^{¶¶} 73 [33, 130] ^{##}	21 [0, 162] ^{¶¶} 25 [0, 82] ^{##}
Osse et al. ¹⁰	Wrist	AW 60s	0-6 days	–	75 (36) ^{***, †††} 72 (59) ^{***, †††} 39 (30) ^{***, †††}	16 (14) ^{***, †††} 19 (21) ^{***, †††} 17 (20) ^{***, †††}	–	453 (145) ^{***, †††} 464 (178) ^{***, †††} 594 (203) ^{***, †††}	336 (52) ^{***, †††} 312 (70) ^{***, †††} 323 (83) ^{***, †††}	100 (22) ^{***, †††} 98 (24) ^{***, †††} 80 (31) ^{***, †††}	42 (22) ^{***, †††} 49 (27) ^{***, †††} 48 (34) ^{***, †††}
Winkelman ¹¹	Wrist	MM 60s	24-48 hours	45 68 ^{¶¶¶}	–	–	98 124 ^{¶¶¶}	–	–	–	–
Ono et al. ¹⁶	–	AC-210 120s	6 days	–	–	–	–	–	–	–	–
Grap et al. ¹²	Wrist, Ankle	BOM 1s	22 hours	–	–	–	–	–	–	–	–
Grap et al. ¹³	Wrist, Ankle	–	24 hours	–	–	–	–	–	–	–	–
Duclos et al. ¹⁴	Wrist	AW2MM 60s	10 days	827 (233) ^{###} 846 (166) ^{****}	–	–	–	–	–	–	–

Abbreviations: AC-210 = Active-tracer; BOM = Basic Octagonal Motionlogger; AW = Actiwatch; BTP = BioTrainer-Pro Activity monitor; AW16 = Actiwatch 16 Model 198-11; ML = Motionlogger; AW2MM = Actiwatch-2 Mini Mitter; MML = Mini Motionlogger; MMB = Mini Motionlogger Basic

^{*} Actigraphy Recording Duration = actigraphy recording time specifically in ICU; Redeker^{29,30} applied actigraphy post-operatively in ICU, for up to 7 days thereafter; Osse²⁸ applied actigraphy post-operatively in ICU, for up to 6 days thereafter

[†] Total Activity Time = minutes of actigraphy-recorded activity

[‡] Presented as mean, mean (SD) or median [min, max]. Total Activity Count = total movements per epoch, unless otherwise noted; Immobility = one minute of zero activity. Restlessness Index = sum of percent of total time spent moving and percent of minutes with zero activity (immobile); Grap²⁵ collected data from 11:00-19:00; Mistraletti²⁶ defined daytime as 06:00-20:00, nighttime as 20:00-06:00; Osse^{27,28} defined daytime as 06:00-23:00, nighttime as 23:00-06:00; Winkelman³³ collected data from 10:00-14:00

§ Activity counts per 20 minutes
|| Activity counts per 15 minutes
¶ Worn on wrist
Worn on ankle
** Within 4 hours of neuromuscular blockade discontinuation
†† 20 to 24 hours after neuromuscular blockade discontinuation
‡‡ Within 24 hours of neuromuscular blockade discontinuation
|||| Movements per 60 minutes
¶¶ Delirious cohort
Non-delirious cohort
*** Average of the post-operative sequential periods 1 to 5
††† Non-clinically relevant delirium cohort
‡‡ Short delirium cohort
§§§ Sustained delirium cohort
||||| Day 1 during observation period
¶¶¶ Day 2 during observation period
Average minutes scored as “moving” over a 24-hour period, for the first 48 hours of recording
**** Average minutes scored as “moving” over a 24-hour period, for the last 48 hours of recording

References for Appendices

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