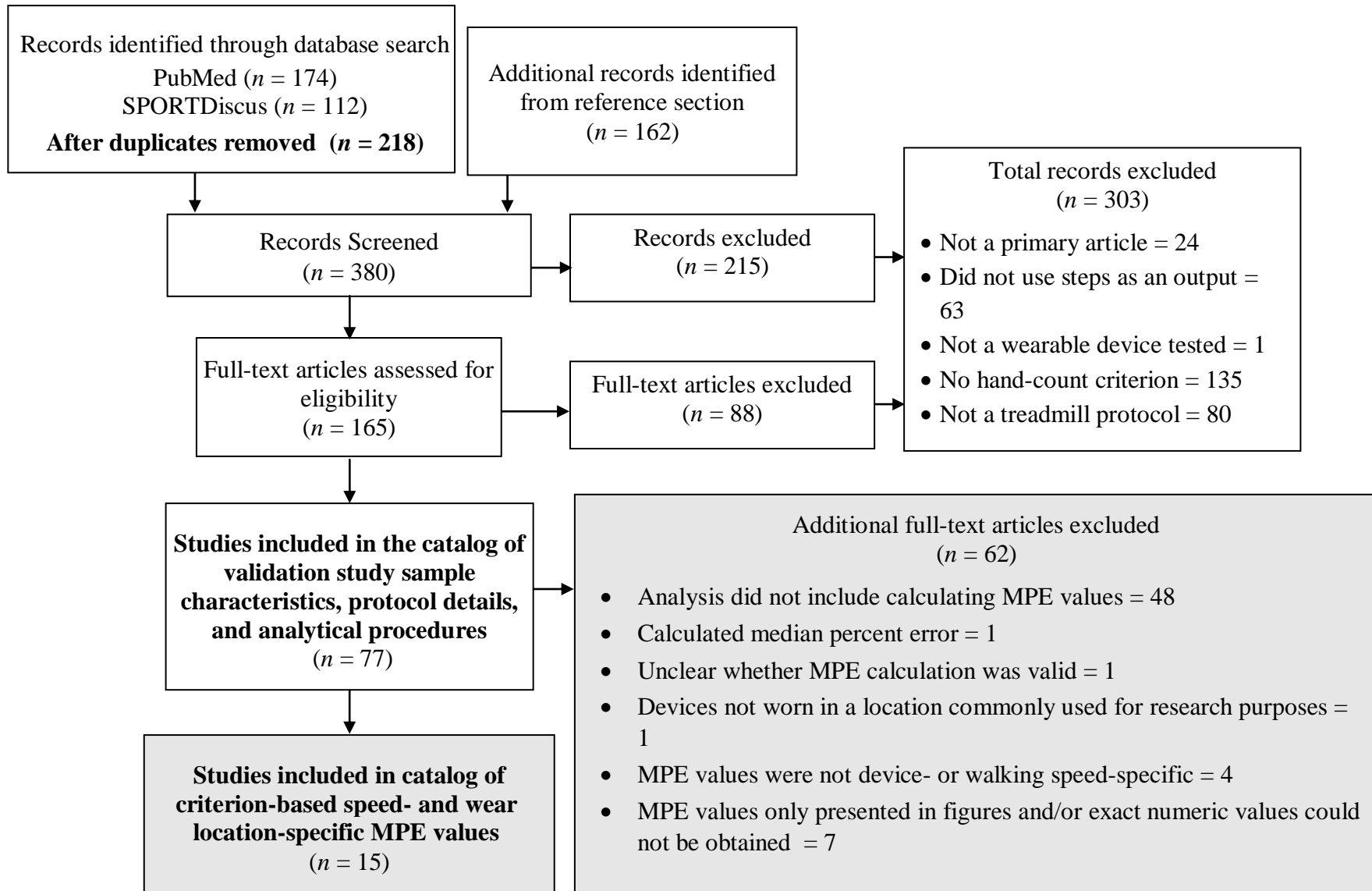Supplementary Material 6: Synthesis of mean percentage error (MPE) values reported by treadmill-based validation studies of step counting devices.

6.1) Search strategy and article screening flowchart

Item	Criteria
Databases	PubMed and SPORTDiscus
Dates	Updated until August 2019; no limit on publication date
Boolean search string	1. (acceleromet* OR pedomet* OR device OR monitor OR wearable) AND ("steps/min*" OR "steps per min*" OR "step count") AND (valid* OR reliab*)
Filters	Human; English

Records identified through database search
PubMed ($n = 174$)
SPORTDiscus ($n = 112$)
After duplicates removed ($n = 218$)

Additional records identified from reference section
($n = 162$)

Records Screened
($n = 380$)

Records excluded
($n = 215$)

Total records excluded
($n = 303$)

- Not a primary article = 24
- Did not use steps as an output = 63
- Not a wearable device tested = 1
- No hand-count criterion = 135
- Not a treadmill protocol = 80

Full-text articles assessed for eligibility
($n = 165$)

Full-text articles excluded
($n = 88$)

Studies included in the catalog of validation study sample characteristics, protocol details, and analytical procedures
($n = 77$)

Additional full-text articles excluded
($n = 62$)

- Analysis did not include calculating MPE values = 48
- Calculated median percent error = 1
- Unclear whether MPE calculation was valid = 1
- Devices not worn in a location commonly used for research purposes = 1
- MPE values were not device- or walking speed-specific = 4
- MPE values only presented in figures and/or exact numeric values could not be obtained = 7

Studies included in catalog of criterion-based speed- and wear location-specific MPE values
($n = 15$)

6.2)   Equation for MPE calculations

$$MPE = \left(\frac{1}{n}\sum \frac{Device - Criterion}{Criterion}\right) * 100\%$$

Where *criterion* is the hand-counted steps from direct observation, *device* is the step count output from the device being tested, and *n* is the total number of step count observations (i.e., person-bouts) being analyzed

6.3)   Tukey boxplots of MPE values reported by treadmill-based validation studies of step counting device, with quantiles weighted by sample size
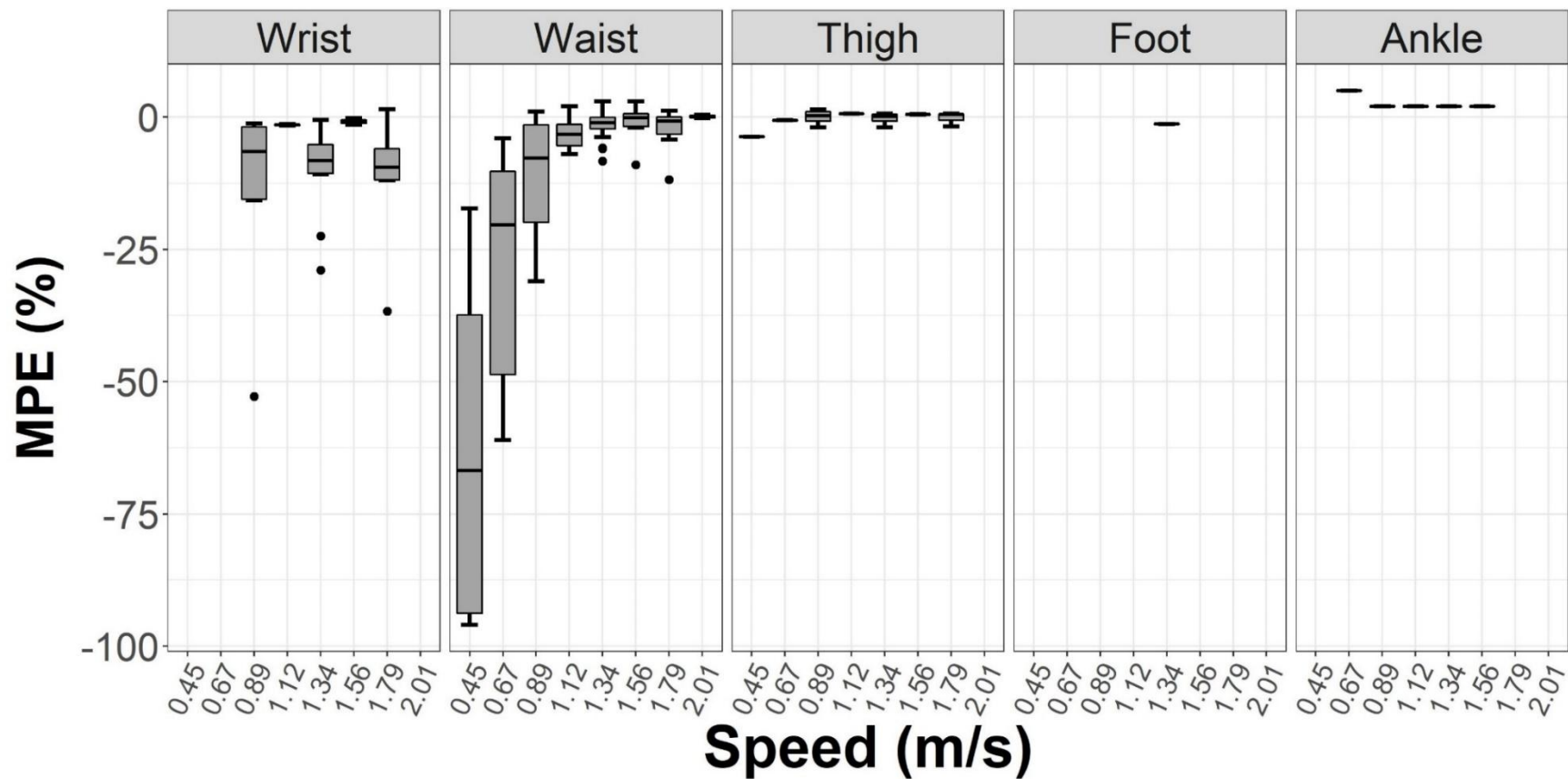
6.4) Summary of MPE values reported by treadmill-based validation studies of step

Wear Location	Value*	0.45 m/s (1.0mph)	0.67 m/s (1.5 mph)	0.89 m/s (2.0 mph)	1.12 m/s (2.5 mph)	1.34 m/s (3.0 mph)	1.56 m/s (3.5 mph)	1.79 m/s (4.0 mph)	2.01 m/s (4.5 mph)
Wrist	**M**	--	--	-10.1	-1.6	-8.4	-1.5	-9.6	--
	Q1;Q3			-15.7;-2.2	-1.6;-1.5	-19.4;-5.4	-1.5;-0.8	-12;-6.6	
	Sample†	0	0	83 [7]	30 [2]	114 [10]	30 [2]	114 [10]	0
Waist	**M**	-87.1	-20.6	-7.9	-3.8	-0.7	-0.3	-1.0	-0.1
	Q1;Q3	-96.0;-40.4	-49.9;-20.2	-21.9;-2.4	-5.4;-1.9	-1.9;0	-1.2;0.6	-3.6;-0.2	-0.2;0.2
	Sample†	14 [6]	109 [6]	161 [20]	201 [8]	258 [20]	244 [12]	111 [12]	43 [4]
Thigh	**M**	-3.7*	-0.6*	0.0	0.6	-0.1	0.5	-0.4	--
	Q1;Q3			-1.2;1.1	0.6;0.6	-1.2;0.5	0.4;0.5	-1.4;0.5	
	Sample†	42 [1]	42 [1]	115 [4]	63 [2]	115 [4]	63 [2]	73 [3]	0
Foot	**M**	--	--	--	--	-1.3*	--	--	--
	Q1;Q3								
	Sample†	0	0	0	0	22 [1]	0	0	0
Ankle	**M**	--	5.0*	2.0*	2.0*	2.0*	2.0*	--	--
	Q1;Q3								
	Sample†	0	24 [1]	24 [1]	24 [1]	24 [1]	24 [1]	0	0

Abbreviations: M = median, Q1 = first quartile, Q3 = third quartile

Values of M, Q1, and Q3 are weighted by study sample size and their units are percent (%)

† Presented as: # person-bouts [# reported values]. Person-bouts represent (sample size)*(bouts per participant testing a device at respective speed and wear location) summed across all studies. Reported values represent total numbers of MAPE values aggregated from individual studies for a device at respective speed and wear location

* For speed-wear location combinations with only one reported value, only that value is presented

counting devices.

6.5) **Summary of MPE values reported by treadmill-based validation studies of step counting devices by device make/model.**

Device Make/Model	0.45 m/s (1.0 mph)	0.67 m/s (1.5 mph)	0.89 m/s (2.0 mph)	1.12 m/s (2.5 mph)	1.34 m/s (3.0 mph)	1.56 m/s (3.5 mph)	1.79 m/s (4.0 mph)	2.01 m/s (4.5 mph)
Wrist-Worn Devices:								
ActiGraph GT3X	--	--	--	--	-28.9*	--	-36.7*	--
Fitbit Charge	--	--	--	--	-7.9*	--	-10.1*	--
Fitbit Charge HR	--	--	-1.4*	-1.6*	-0.6*	-1.5*	-1.5*	--
Fitbit Flex	--	--	-8.8 [6.6]	--	-7.2 [2.6]	--	-10.5 [1.9]	--
Garmin Vivofit	--	--	-2.3*	--	-5.6*	--	-5.4*	--
Jawbone UP 24	--	--	-15.3*	--	-10.8*	--	-7.6*	--
Mi Band 2	--	--	-1.2*	-1.3*	-0.9*	-0.2*	1.5*	--
Nike+ Fuelband	--	--	-52.8*	--	-22.5*	--	-12*	--
Waist-Worn Devices:								
Actical	--	--	-20.8 [3.1]	--	-3.8*	-1.7*	-1*	-0.1*
ActiGraph GT1M	--	-61*	-31*	-7*	-4.8 [3.1]	-9*	--	--
ActiGraph GT1M (LFE)	--	-7*	-1*	-2*	-2*	-2*	--	--
ActiGraph GT3X	--	-58*	-31*	-6*	-0.5 [0.6]	-2*	0.9*	--
ActiGraph GT3X (LFE)	--	-4*	1*	2*	3*	3*	--	--
Fitbit One	--	--	-3.2 [1.6]	--	-0.6 [0.9]	--	-0.3 [1.6]	--
Fitbit Zip	-56.6 [55.7]	--	-1.8 [2.4]	--	-5.8*	--	-3.4*	--
Jawbone	--	--	--	--	-2.6*	--	-4.3*	--
New Lifestyles NL-2000	--	-20.6*	--	-4.5*	--	-0.5*	--	--
Omron HJ-112	--	--	-1.9*	0.5*	0.2*	0.2 [0.1]	--	-0.2*
Omron HJ-321	--	--	-13.1*	--	-1.4*	--	-0.2*	--
Omron HJ-720	-65.1 [43.6]	--	0.6*	--	--	--	--	--
SportBrain iStep X1	--	--	-1.3*	--	-0.5*	--	-3.2*	--
Walk4Life Elite	--	--	-7.6*	--	--	0.7*	--	0.4*
Yamax Digiwalker CW-700	--	--	-17.4*	--	-2.1*	--	0.5*	--
Yamax Digiwalker CW-701	--	--	-7.9*	--	-0.7*	--	-0.6*	--
Yamax Digiwalker SW-200	-66.8 [28.7]	-20.1*	-23.7 [1.2]	-5.2*	--	-0.3 [0.9]	--	0.2*
Yamax Digiwalker SW-401	--	--	--	--	0.5*	--	--	--
Yamax Digiwalker SW-701	--	--	-19.3*	-2*	-1.3 [5.9]	0.9*	-11.8*	--
Thigh-Worn Devices:								
activPAL	-3.7*	-0.6*	0.4 [1.3]	0.6 [0]	0 [0.9]	0.5 [0.1]	0.2 [1.1]	--
Foot-Worn Devices:								
ActiPed	--	--	--	--	-1.3*	--	--	--
Ankle-Worn Devices:								
StepWatch 3	--	5*	2*	2*	2*	2*	--	--

All values are presented as: mean [SD]% and weighted by sample size

* Only one reported value (i.e., device tested in only one study at respective speed)

6.6)   Descriptions of treadmill-based validation studies from which speed- and wear location-specific MPE values were obtained.

Study	*n*	Person-bouts[†]	Device Makes/Models Tested by Wear Location	Walking Speeds
Beevi 2016[1]	14	42	*Waist*: Fitbit Zip, Omron HJ-720, Yamax Digiwalker SW-200	0.28, 0.56, 0.83 m/s
Brown 2013[2]	22	22	*Waist*: ActiGraph GT1M, Yamax Digiwalker SW-401 *Foot*: ActiPed	1.33 m/s
Chow 2017[3]	31	62	*Wrist*: ActiGraph GT3X, Fitbit Charge, Fitbit Flex *Waist*: ActiGraph GT3X, Fitbit One, Jawbone	1.39, 1.81 m/s
Diaz 2016[4]	13	39	*Wrist*: Fitbit Flex *Waist*: Fitbit One	0.85, 1.34, 1.79 m/s
Dueker 2012[5]	17	51	*Waist*: SportBrain iStep X1, Yamax Digiwalker SW-701	0.89, 1.34, 1.79 m/s
Duncan 2007[6]	85	255	*Waist*: New Lifestyles NL-2000, Yamax Digiwalker SW-200	0.7, 1.1, 1.5 m/s
Feito 2015[7]	24	120	*Waist*: ActiGraph GT1M, ActiGraph GT1M (LFE), ActiGraph GT3X, ActiGraph GT3X (LFE) *Ankle*: StepWatch 3	0.67, 0.9, 1.12, 1.33, 1.57 m/s
Hasson 2009[8]	92	276	*Waist*: Omron HJ-112, Yamax Digiwalker SW-701	1.12, 1.34, 1.56 m/s
Huang 2016[9]	40	120	*Wrist*: Fitbit Flex, Garmin Vivofit, Jawbone UP 24, Nike+ Fuelband *Waist*: Fitbit One, Fitbit Zip, Omron HJ-321, Yamax Digiwalker CW-701	0.9, 1.33, 1.78 m/s
Johnson 2015[10]	43	129	*Waist*: Actical, Omron HJ-112, Walk4Life Elite, Yamax Digiwalker SW-200	0.89, 1.56, 2.01 m/s
Kanoun 2009[11]	42	168	*Thigh*: ActivPAL	0.45, 0.67, 0.9, 1.33 m/s
Lutzner 2014[12]	43	215	*Thigh*: ActivPAL	0.9, 1.1, 1.3, 1.6, 1.8 m/s
Oliver 2011[13]	10	30	*Waist*: Actical, Yamax Digiwalker CW-700 *Thigh*: ActivPAL	0.9, 1.33, 1.78 m/s
Ryan 2006[14]	20	100	*Thigh*: ActivPAL	0.9, 1.12, 1.33, 1.56, 1.78 m/s
Tam 2018[15]	30	150	*Wrist*: Fitbit Charge HR, Mi Band 2	0.9, 1.12, 1.33, 1.54, 1.78 m/s

† Person-bouts = (sample size) * (number of bouts per participant)

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