

1 **A systematic review of one-legged balance performance and falls risk in community-**
2 **dwelling adults**

3
4 Joanna M Blodgett ^{a*}; Jodi P Ventre^{bc}; Richard Mills^b; Rebecca Hardy^d; Rachel Cooper^b

5
6 ^a Institute of Sport, Exercise & Health, Division of Surgery & Interventional Science,
7 University College London, 170 Tottenham Court Road, W1T 7HA, London, UK

8 ^b Department of Sport and Exercise Sciences, Musculoskeletal Science and Sports Medicine
9 Research Centre, Manchester Metropolitan University, Oxford Road, M15 6BH, Manchester,
10 UK

11 ^c Department of Psychology, Health, Psychology and Communities Research Centre,
12 Manchester Metropolitan University, Bonsall Street, M15 6GX, Manchester, UK

13 ^d CLOSER, Social Research Institute, University College London, 55-59 Gordon Square,
14 WC1H 0NU, London, UK

15
16 * Corresponding Author:

17 Joanna M Blodgett

18 Institute of Sport, Exercise & Health

19 Division of Surgery & Interventional Science

20 University College London

21 170 Tottenham Court Road

22 W1T 7HA

23 London, UK

24 Email: joanna.blodgett@ucl.ac.uk

25

26

27 **Abstract**

28 **Objective:** The aim of this systematic review was to synthesise all published evidence on
29 associations between one-legged balance performance and falls. **Methods:** Medline,
30 EMBASE, CINAHL and Web of Science were systematically searched (to January 2021) to
31 identify peer-reviewed, English language journal articles examining the association between
32 one-legged balance performance and falls in community-dwelling adults. **Results:** Of 4 310
33 records screened, 55 papers were included (n=36 954 participants). There was considerable
34 heterogeneity between studies including differences in study characteristics, ascertainment of
35 balance and falls, and analytical approaches. A meta-analysis of the time that individuals could
36 maintain the one-legged balance position indicated that fallers had worse balance times than
37 non-fallers (standardised mean difference: -0.29(95%CI:-0.38,-0.20) in cross-sectional
38 analyses; -0.19(-0.28,-0.09) in longitudinal analyses), although there was no difference in the
39 pooled median difference. Due to between-study heterogeneity, regression estimates between
40 balance and fall outcomes could not be synthesised. Where assessed, prognostic accuracy
41 indicators suggested that one-legged balance was a poor discriminator of fall risk; for example,
42 5 of 7 studies demonstrated poor prognostic accuracy (Area Under the Curve <0.6), with most
43 studies demonstrating poor sensitivity. **Conclusions:** This systematic review identified 55
44 papers that examined associations between balance and fall risk, the majority in older aged
45 adults. However, the evidence was commonly of low quality and results were inconsistent.
46 This contradicts previous perceptions of one-legged balance as a useful fall risk tool and
47 highlights crucial gaps that must be addressed in order to translate such assessments to clinical
48 settings.

49 **Keywords:** one-legged balance; falls; systematic review; community-dwelling

50

51 1.0 INTRODUCTION

52 Falls are a leading cause of injury, functional impairment, and death in older adults(Ungar et
53 al., 2013). Globally, an estimated 28 to 50% of individuals over the age of 65 reported a fall in
54 the past year(Soriano et al., 2007; WHO, 2007). Falls have substantial impacts at both
55 individual and population levels. A recent Global Burden of Disease study estimated that falls
56 resulted in 16.7 million years of life lost, 19.3 million years lived with disability and 35.9
57 disability-adjusted life years(James et al., 2020). This is consistent with World Health
58 Organisation reports suggesting that falls are the leading cause of injury-related death in adults
59 aged ≥ 65 years(WHO, 2007) and estimating that annually, falls cause 684,000 deaths with
60 over 37 million falls severe enough to warrant medical attention(WHO, 2021). Annual medical
61 costs associated with falls are estimated to be \$50 billion in the USA and £2.3 billion in the
62 UK and continue to rise(Florence et al., 2018; NICE guideline, 2013). There is emerging
63 evidence that midlife may represent an important period for fall-related interventions, with
64 pooled analysis demonstrating that fall prevalence is already significant in adults aged 40 to 64
65 years, ranging from 8.7% to 31.1% (Peeters et al., 2019; Peeters et al., 2018).

66 Successful fall prevention strategies must consider effective screening tools, targeted
67 interventions that mitigate risk factors, and modification of home or community environments
68 to reduce extrinsic hazards (Dellinger, 2017; Hopewell et al., 2018). Of the many risk factors
69 studied, history of falls and balance or gait impairments have been identified as the two
70 strongest predictors of future falls(Ganz et al., 2007). Given the role of balance in maintaining
71 postural stability, improving balance ability in older adults is frequently a target of falls
72 prevention interventions (Sherrington et al., 2019). Further, balance assessments are commonly
73 used in research and clinical settings as a prognostic tool to identify those at higher risk of
74 falling(Springer et al., 2007; Vereeck et al., 2008). Balance tests in these settings are highly
75 heterogeneous. For example, some balance tests use performance-based measures such as the
76 one-legged stand or functional reach test, while others rely on cumulative, subjective measures
77 such as the Tinetti Assessment Test or the Berg Balance Scale, which consist of 9 and 14
78 balance-related tasks, respectively, each scored on 3 to 5 point scales(Mancini and Horak,
79 2010).

80 Previous systematic reviews have examined the utility of single (Barry et al., 2014; Lima et al.,
81 2018; Moore and Barker, 2017; Okubo et al., 2021; Rosa et al., 2019) or multiple (Gates et al.,
82 2008; Kozinc et al., 2020; Lusardi et al., 2017; Okubo et al., 2021; Power et al., 2014) balance

83 measures in predicting falls. These reviews commonly focused on older adults (≥ 60 years) and
84 had broad inclusion criteria; for example, studies from any setting (e.g. clinical vs community-
85 dwelling) or that used any balance measure were often eligible for inclusion. No review has
86 focused exclusively on the one-legged balance test and reviews of multiple balance measures
87 reported conflicting evidence on one-legged balance test and fall risk (Kozinc et al., 2020;
88 Lusardi et al., 2017; Power et al., 2014). In addition, the broad search terms used to capture
89 multiple measures of balance in a single review did not identify all studies examining one-
90 legged balance and falls.

91 The one-legged balance test is one of the most commonly used balance tests and is widely
92 considered to be cost-effective and feasible in both clinical and research settings(Bohannon,
93 2006; Jonsson et al., 2004; Mancini and Horak, 2010; Michikawa et al., 2009; Springer et al.,
94 2007). Proponents of the test suggest that it should be implemented into primary care to help
95 identify individuals at higher risk of falling and other poor health outcomes(Kozinc et al., 2020;
96 Michikawa et al., 2009; Nickelston, 2014), emphasising a clear need to systematically review
97 and synthesise the evidence on one-legged balance performance and fall risk. To address this
98 gap and provide a robust summary of available evidence, we undertook a systematic review
99 and meta-analyses to synthesise all published evidence of associations between one-legged
100 balance performance and fall risk in community-dwelling adults. We hypothesised that there
101 would be consistent evidence of an association between better one-legged balance performance
102 and lower fall risk.

103 **2.0 METHODS**

104 This systematic review follows the Preferred Reporting Items for Systematic Reviews and
105 Meta-Analyses (PRISMA) guidelines(Moher et al., 2009) and the study protocol was registered
106 with PROSPERO (CRD42020160413)(Blodgett et al., 2020c).

107 ***2.1 Eligibility criteria***

108 Studies published in peer-reviewed journals were eligible for inclusion if they examined the
109 association between one-legged balance performance and any fall outcome in a community-
110 dwelling sample. Studies were excluded if they were: published in a non-English language
111 journal; systematic reviews or intervention studies; or if they considered a specific clinical
112 sample (e.g. those with Parkinson's disease).

113 ***2.2 Search strategy***

114 We searched Medline, EMBASE, CINAHL and Web of Science for all available articles from
115 inception to January 2021. Two distinct search arms were combined using the Boolean term
116 “AND”. All possible synonyms and truncations of one-legged balance synonyms (e.g. single
117 leg, flamingo or unipedal stand) comprised one arm, while “fall” with any truncation
118 constituted the other. See Appendix A for the complete search strategy. Reference lists of all
119 included articles were independently searched by two authors to identify additional studies.

120 **2.3 Study selection**

121 All articles were uploaded into Mendeley and Rayyan(Ouzzani et al., 2016), which were used
122 to remove duplicates and manage the two-stage screening process. In both the title-abstract and
123 full-text screening stage, two authors (JB, JV or RM) independently screened all potential
124 papers for inclusion. In the full-text screening stage, each author recorded the reason for
125 exclusion following a hierarchical list of five criteria (outlined in Figure 1). Discrepancies in
126 screening decision or exclusion rationale were resolved through discussion between authors.

127 **2.4 Data extraction**

128 Two authors (JB, JV, RM or RC) independently extracted data and any conflicts were resolved
129 through discussion. For all included papers, the following data were extracted using a standard
130 proforma in Google Forms (see Appendix B): demographic characteristics (country, study
131 design, exclusion criteria, sample size, sex and age), one-legged balance (assessment protocol
132 details), falls (definition, prevalence, data collection protocol, outcome type), statistical
133 methods, and effect estimates. WebPlotDigitizer was used to extract data that were presented
134 in graphs and not tables(Rohatgi, 2020). A modified version of the Newcastle-Ottawa Risk of
135 Bias Scale was used to appraise the quality of each included study (see Appendix B, part 6).
136 Scores ranged from zero (lowest quality) to seven (highest quality). Any discrepancies in scores
137 were discussed and resolved by authors.

138 **2.5 Narrative synthesis**

139 Narrative synthesis of study characteristics, one-legged balance measurement and falls
140 measurement was first conducted following established guidelines(Popay et al., 2006). Results
141 are presented by fall outcomes: any fall (0 vs 1+ fall), recurrent falls (0-1 vs 2+ falls) or
142 injurious falls (non-injurious or 0 injurious falls vs 1+ injurious falls). For associations between
143 one-legged balance and falls, meta-analyses were conducted where there were comparable
144 estimates from three or more studies and a narrative synthesis of estimates was conducted if
145 meta-analyses were not possible. It was decided *a priori* that estimates could not be synthesised

146 in meta-analyses if there were differences in temporality (e.g. cross-sectional or longitudinal),
147 model adjustment (e.g. unadjusted or adjusted) or balance dichotomisation (e.g. $\leq 5s$, $\leq 30s$,
148 etc.).

149 Where studies presented multiple estimates for an association (e.g. balance times for both legs,
150 best and average balance trials, multiple balance cut-points or results for balance with eyes
151 open and closed), a single result was used in the main analysis although all results are presented
152 in Appendix C. The result provided in the main analysis is selected based on comparability
153 with other papers (e.g. common characteristics as demonstrated in the initial narrative
154 synthesis) and completeness of data (e.g. estimates, error terms). Where studies presented
155 associations for multiple fall outcomes, effect estimates for each outcome were considered in
156 each relevant section. To maximise comparison of results between studies, odds ratios (OR)
157 and prognostic indicators (i.e. sensitivity, specificity, positive predictive value, negative
158 predictive value) were calculated from proportions and sample sizes, where possible.

159 **2.6 Meta-analyses**

160 Meta-analysis of median differences was conducted using the *metamedian* package in R, which
161 provides an estimate for the weighted pooled difference of median balance times between
162 fallers and non-fallers (McGrath et al., 2020). Meta-analysis of standardised mean difference
163 (SMD) in balance time between fallers and non-fallers was conducted using the package *meta*
164 in R to calculate Hedge's *g* (Balduzzi et al., 2019; Lakens, 2013). Hedge's *g* (i.e. SMD) is a
165 measure of the effect size and is calculated as the difference in mean balance times between
166 groups divided by the standard deviation of the combined sample. Due to difference in the
167 length of balance trials between studies, raw mean difference times were not appropriate due
168 to dissimilar scales and ceiling effects. Where standard errors (SE) were missing or could not
169 be calculated from available information, inclusion of studies in the meta-analysis was
170 maximised using a prognostic imputation method to impute SE (Ma et al., 2008). Random-
171 effects models were used to estimate and compare SMDs by cross-sectional and longitudinal
172 subgroups. As a supplementary analysis, we further stratified by age group (< 75 years, ≥ 75
173 years). The I^2 statistic was considered as the indicator of between-study heterogeneity, where
174 25%, 50% and 75% suggest low, moderate and high heterogeneity, respectively (Higgins et al.,
175 2003). Finally, publication bias was examined using the Egger test and visual inspection of a
176 funnel plot (Sterne and Egger, 2005). To ensure no single study was driving the result, a
177 sensitivity analysis repeated the Egger test multiple times, removing each study in turn. Due to

178 heterogeneity outlined in section 2.5, meta-regression was not possible for any fall outcome.
179 All meta-analyses were conducted in R Studio version 1.2.5.

180 **3.0 RESULTS**

181 Our database searches identified a total of 4,310 unique records. After the two-stage screening
182 and additional papers identified via the reference list search, a total of 55 papers are included
183 in the review(Andresen et al., 2006; Ansai et al., 2016; Arai et al., 2020; Beauchet et al., 2010;
184 Bergland and Wyller, 2004; Blain et al., 2021; Bongue et al., 2011; Briggs et al., 1989; Buatois
185 et al., 2006; Buatois et al., 2010; Cho and Kamen, 1998; Choy et al., 2008; Choy et al., 2007;
186 Crenshaw et al., 2020; de Rekeneire et al., 2003; Delbaere et al., 2010; Depasquale and
187 Toscano, 2009; Ek et al., 2019a; Ek et al., 2019b; El-Sobkey, 2011; Eto and Miyauchi, 2018;
188 Gerdhem et al., 2005; Hasegawa et al., 2019; Hashidate et al., 2011; Heitmann et al., 1989;
189 Ikegami et al., 2019; Jalali et al., 2015; Kwan et al., 2011; Lim et al., 2016; Lin et al., 2004b;
190 MacRae et al., 1992; Mahoney et al., 2019; Moreira et al., 2017; Muir et al., 2010; Mulasso et
191 al., 2017; Nevitt et al., 1989; Niam and Wee, 1999; Park et al., 2020; Porto et al., 2020; Rossat
192 et al., 2010; Sampaio et al., 2013; Shimada et al., 2009; Shimada et al., 2011; Shin et al., 2012;
193 Shinohara et al., 2020; Swanenburg et al., 2013; Thomas and Lane, 2005; Tinetti et al., 1988;
194 Toulotte et al., 2006; Vellas et al., 1998; Vellas et al., 1997; Welmer et al., 2017; Yamada and
195 Ichihashi, 2010; Yamada et al., 2012; Yamada et al., 2020)(see Figure 1). The 55 papers use
196 data from 51 study samples, with multiple papers using data from the Swedish National Study
197 on Ageing and Care in Kungsholmen(Ek et al., 2019a; Ek et al., 2019b; Welmer et al., 2017),
198 the Albuquerque Falls Study(Vellas et al., 1998; Vellas et al., 1997) and an unnamed French
199 cohort(Beauchet et al., 2010; Bongue et al., 2011). Characteristics of all studies are presented
200 in Table 1 and Appendix C.

201 **3.1 Description of studies, balance and falls**

202 **3.1.1 Study characteristics**

203 Thirty papers assessed cross-sectional associations between balance and falls, 22 assessed
204 longitudinal associations (follow-up range: 12 months to 10 years) and 3 assessed both. Studies
205 were conducted in sixteen different countries (see Table 1), with the most common continents
206 being Asia (n=19), North America (n=12) and Europe (n=12). Sixteen studies used data from
207 previously established cohorts and four were case-control studies. A total of 36,954 individuals
208 were included across the 51 study samples, with individual sample sizes ranging from 16 to
209 7,463. Eight studies considered women-only samples, while the remaining 43 considered both

210 men and women. In mixed-sex studies, the overall proportion of women was 58.6% and ranged
211 from 30% to 84.4%. The mean age, where reported, ranged from 55 to 81.5 years and the most
212 commonly studied age group was aged ≥ 65 years ($n=26$). The mean and median study quality
213 scores on the Newcastle-Ottawa Risk of Bias Scale were both 4, with a range from 1 (lowest
214 quality) to 7 (highest quality); scores for each individual item are provided in Appendix D.

215 *3.1.2 Ascertainment of one-legged balance*

216 As some of the papers reporting on the same study population provided different descriptions
217 of one-legged balance, methods for all 55 papers are summarised below. Most papers recorded
218 continuous balance time ($n=44$), 10 studies collected a binary measure (e.g. <5 vs ≥ 5 s) and the
219 final paper recorded the number of times the participant's foot touched the ground during a
220 continuous 30 second trial. The most common lengths of the continuous trials were 30 ($n=14$)
221 and 60 ($n=9$) seconds, with a range of 10 to 120 seconds; ten studies did not report the maximal
222 time. Continuous balance times were analysed in 31 papers, 22 used distinct categorical or
223 binary cut-points and 1 paper analysed both continuous and binary balance times. Fifteen
224 different cut-points were used to create distinct binary groups; the most common was <5 or ≥ 5
225 seconds ($n=8$).

226 The number of balance trials ranged from a single trial to 24 trials. Of the 36 papers that
227 conducted multiple trials, different strategies were used to select the balance time for analysis;
228 this included the best time ($n=18$), worst time ($n=1$) or average time ($n=8$). The others did not
229 specify which was used or analysed multiple balance times. Eight papers conducted both eyes
230 open and eyes closed trials, 25 conducted eyes open only and 22 did not describe whether eyes
231 were open or closed. Similarly, 20 papers conducted trials on each leg, 23 studies instructed
232 individuals to use their dominant or preferred leg only, one study used the non-dominant leg
233 and the remaining 11 studies did not provide a description. Finally, the majority of papers did
234 not provide details of instructions on the body position required in protocols (see Appendix C).

235 *3.1.3 Ascertainment of falls*

236 Thirty-six studies assessed falls retrospectively (e.g. fall in last 12 months), thirteen
237 prospectively and two studies measured falls both retrospectively and at follow-up. Of the 38
238 retrospective fall assessments, 22 used self-reported questionnaires, 15 collected data in
239 interviews and one was based on clinician referral. Prospective collection of falls data included
240 diary or post card submission ($n=4$), regular phone calls ($n=5$), linked health records ($n=1$),
241 postal questionnaires ($n=1$) and five studies combined diary or postcard submissions with

242 phone calls.

243 As papers that used the same sample examined different follow-up periods and fall outcomes,
244 summary characteristics are, once again, provided at the paper (n=55) rather than study level.
245 Twelve months was the most frequent time period for fall reporting across both prospective
246 and retrospectively collected data (n=41), followed by 2 years (n=5); the remaining 9 studies
247 each had a distinct follow-up period (range: 3 months to 10 years). Eight studies examined
248 multiple fall outcomes. The most common outcome was any fall (e.g. 0 vs 1+ fall; n=38)
249 followed by recurrent falls (e.g. 0-1 vs 2+ falls; n=7) and injurious falls (e.g. no falls/non-
250 injurious falls vs any injurious falls; n=7). Additionally, eight studies considered the number
251 of falls, either continuously (n=4) or in categories (e.g. 0,1,2+ falls; n=4) and one study
252 considered an aggregate outcome of 2+ non-injurious falls or 1+ injurious fall.

253 The prevalence of falls ranged from 11.0% to 71.2% (median: 28.9%). Many papers described
254 their definition of a fall (n=36), but 19 did not. Of the 36 papers that provided a falls definition,
255 ten created or adapted their own. Exact phrasing was taken from six existing definitions and
256 was most frequently attributed to the Kellogg Working Group(1987) (n=8) or Tinetti(Tinetti et
257 al., 1988) (n=7) (see Appendix E for falls definitions).

258 **3.2 Any fall (no fall vs 1+ falls)**

259

260 *3.2.1 Median differences*

261 Given the skewed distribution of one-legged balance times, the assumption of normally
262 distributed data needed for parametric tests (e.g. t-tests) is not met, indicating that non-
263 parametric tests (e.g. Mann Whitney U tests) are more appropriate(Nahm, 2016). None of the
264 8 studies (range: n=30 to 213) that used the Mann Whitney U test found a statistically
265 significant difference in balance times in fallers and non-fallers. A meta-analysis of the four
266 studies that provided median balance times, using the median of the difference of medians
267 method(McGrath et al., 2020), provided further support for no difference between groups (1s
268 (95% CI: -1.2,8.9); see Table 2).

269 *3.2.2 Mean differences*

270 Most studies ignored the non-normal distribution of one-legged balance times, with 15 cross-
271 sectional studies and 9 longitudinal studies presenting mean (SD) balance times in fallers and
272 non-fallers (total n=6 894 across all studies). Meta-analyses suggested that fallers had lower
273 mean balance times than non-fallers (SMD= -0.29 (95% CI: -0.38,-0.20)) in cross-sectional

274 analyses and a similar pattern was seen in longitudinal analyses (SMD= -0.19 (-0.28,-0.09))
275 (see Figure 2). The SMD was smaller for longitudinal associations, although the test for
276 subgroup differences did not reach statistical significance (p=0.09). Estimated heterogeneity in
277 study outcomes in these meta-analyses was low for both cross-sectional (I²=14% (0,50%)) and
278 longitudinal (I²=0% (0,60%)) analyses. Visual inspection of the funnel plot and Egger test
279 (p=0.05) suggested that there may be minimal publication bias (see Appendix F); however, this
280 was primarily driven by Cho and Kamen(1998; n= 16) and Hashidate et al.(2011; n=30)(p=0.16
281 when removed), although there was no impact on the cross-sectional SMD when Cho and
282 Kamen(1998) and Hashidate et al. (2011) were removed from the meta-analysis (-0.28 (95%
283 CI: -0.37,-0.19)).

284 When stratified by age, there was evidence to suggest that associations were stronger in
285 younger individuals (see Appendix G). In longitudinal analyses, the SMD in favour of non-
286 fallers was larger in studies with a mean age <75 years (SMD= -0.30 (-0.46,-0.15)) compared
287 to those with a mean age ≥ 75 years ((SMD= -0.13 (-0.25,-0.01)). In cross-sectional studies,
288 there was strong overlap in 95% confidence intervals of the SMD of both age groups; it is
289 noteworthy that 7 of 10 studies with a mean age <75 years found a significant association
290 ((SMD= -0.26 (-0.37,-0.16)) compared to just 1 of 4 studies with a mean age ≥ 75 years
291 ((SMD= -0.42 (-0.71,-0.13)).

292 3.2.3 Regression estimates

293 Meta-analyses of regression outcomes for any fall outcome were not possible due to
294 heterogeneity in temporality, model adjustment and balance dichotomisation, as outlined in
295 section 2.5. Estimates for risk of any fall are presented in Figure 3, with a detailed table of all
296 estimates and study details in Appendix H. Patterns of association were similar across estimate
297 type (e.g. OR per 1s, OR per low balance cut-point, relative risk (RR) per low balance cut-
298 point) and across cross-sectional and longitudinal models. In unadjusted models, poorer
299 balance performance was associated with increased risk of a fall in seven of ten studies, with
300 three studies reporting non-significant results (Figure 3A-C). Two additional studies, Vellas et
301 al.(1998) and Blain et al.(2021), reported positive associations in men but no associations in
302 women (Figure 3A and 3B). Significant odds ratios in unadjusted models ranged from 1.5
303 (1.2,1.8) for those with a balance time <12.7s(Bongue et al., 2011) to 8.40 (1.10,64.26) in those
304 with a balance time <55.4s(Eto and Miyauchi, 2018)(Figure 3B).

305 In adjusted models, most studies (n=9/12) reported no association between balance time and

306 falls. The most commonly included covariates were age, sex, body size and comorbidities;
307 covariates for each model are detailed in Appendix H. Weak associations remained in three
308 studies; a one second increase in balance time was associated with lower risk of falling in two
309 cross-sectional studies(Hasegawa et al., 1989; Moreira et al., 2017), while Muir et al.(2010)
310 reported that those who balanced for <10s had a 1.58 (1.03,2.41) times higher risk of falling
311 after a 12-month follow-up. Only five studies provided unadjusted and adjusted estimates, with
312 the adjusted association remaining in Muir et al.(2010) only (Figure 3C).

313 **3.3 Recurrent falls (0-1 fall vs 2+ falls)**

314 Two studies compared median or mean balance times of recurrent fallers; Porto et al. (2020)
315 reported no difference in mean balance time between single fallers and recurrent fallers (19.1s
316 \pm 10.4 vs 18.2s \pm 10.2; p=0.84), while Thomas and Lane (2005) reported lower median balance
317 times in recurrent fallers (0.43s (interquartile range: 1.57) compared to single fallers and non-
318 fallers (2.71s (2.59); p<0.05). All other studies that examined recurrent falls used regression
319 models, with sample sizes ranging from 30(Thomas and Lane, 2005) to 7 643(Rossat et al.,
320 2010). In unadjusted models, six of nine studies reported an association between lower balance
321 time and higher risk of falling two or more times (Figure 4, Appendix H), with no association
322 in the remaining studies(Beauchet et al., 2010; Buatois et al., 2006; Swanenburg et al., 2013).
323 OR estimates ranged from 1.6 (1.2, 2.2) in those who maintained balance for <2s to 15.22
324 (1.72,133.95) in those who balanced for <1.02s(Thomas and Lane, 2005).

325 Similar to above, comparison of unadjusted and adjusted estimates was possible in three studies
326 (Figure 4). In the first of these by Jalali et al.(2015), those with low balance time (\leq 12.7s) were
327 more likely to fall multiple times than those with better balance ($>$ 12.7s) (unadjusted OR: 8.54
328 (95% CI: 4.86,14.99)); this association attenuated to 3.71 (95% CI not reported) after
329 adjustment for age, body mass index, diabetes, functional reach and the Romberg test. In
330 another study, Nevitt et al.(1989) found that the association between balance (<2s) and falls in
331 an unadjusted model was fully attenuated after adjustment for race, fall history, comorbidities
332 and other physical performance tests. Finally, Rossat et al.(2010) reported that low balance
333 time (\leq 5s) was associated with increased risk of recurrent falls even after adjustments
334 (unadjusted Incident Rate Ratio (IRR) 1.85 (1.67,2.05); adjusted IRR 1.55 (1.39,1.73), adjusted
335 for age, sex, medications, cognitive scores and the sit to stand test).

336 **3.4 Injurious falls (non-injurious or 0 injurious falls vs 1+ injurious falls)**

337 There was inconsistent evidence of an association between balance times and injurious falls in
338 the eight papers that assessed this (Appendix H). Two studies reported no associations between
339 balance and injurious falls in both unadjusted and adjusted models(Andresen et al., 2006; Muir
340 et al., 2010), while another reported that those with balance times in the bottom 50% of the
341 sample had 2.4 (1.1, 5.2) times the odds of an injurious fall(Bergland and Wyller, 2004). Vellas
342 et al. 1998 reported higher risk of injurious falls in women (RR: 2.97 (1.86,4.74)) with low
343 balance time but not men (1.79 (0.78,4.15)).

344 Finally, using Swedish cohort data, Ek et al.(2019a;2019b) and Welmer et al.(2017) reported
345 associations between low balance time (<5s) and increased risk of injurious falls as measured
346 by linked hospital data in 17 different models (Appendix H). Here, associations were similar
347 in men and women(Ek et al., 2019a; Ek et al., 2019b), but weakened with longer periods of
348 follow-up (e.g. from 3 years to 10 years)(Ek et al., 2019b; Welmer et al., 2017). Estimates
349 remained after adjustment for age and education (Ek et al., 2019b; Welmer et al., 2017), while
350 adjustment for previous history of falls, activities of daily living and grip strength often
351 attenuated the estimates(Ek et al., 2019b; Welmer et al., 2017). Appendix H outlines the 17
352 models, which considered sex-stratification, multiple follow-up periods and inclusion of
353 different covariates.

354 ***3.5 Other results of relevance***

355

356 ***3.5.1 Prognostic accuracy of the one-legged balance test***

357 Seven studies provided estimates on the prognostic accuracy of the one-legged balance test.
358 Sensitivity, specificity, positive predictive values and negative predictive values could be
359 calculated from sample size and proportions in an additional 11 studies. Similar to the
360 regression estimates, we were unable to conduct a meta-analysis due to variability in cut-points
361 and fall outcome type. There was substantial variability in prognostic accuracy estimates (see
362 Table 3), however most papers reported higher specificity (range: 46.2-90.3%) than sensitivity
363 (16.7-83.5%) and higher negative predictive values (range: 63.4-95.1%) than positive
364 predictive values (range: 12.1-82.4%). Notably, negative predictive values were also higher
365 when considering recurrent falls compared to any fall. When several cut-points were used
366 within the same study sample(Beauchet et al., 2010; Bongue et al., 2011), higher cut-points
367 (e.g. <7.6s or <12.7s) had greater sensitivity but lower specificity compared to a lower cut-
368 point (e.g. <5s). Finally, the area under the curve (AUC) varied from 0.527(Lin et al., 2004b)
369 to 0.766(Depasquale and Toscano, 2009), but was in the range considered as failed

370 discrimination (i.e. 0.5 to 0.6)(Li and He, 2018) for five of seven studies.

371 *3.5.2 Differences in results by balance test conditions*

372 Five studies reported no differences when comparing associations of balance times under eyes
373 open and eyes closed conditions with falls (Briggs et al., 1989; Choy et al., 2007; Heitmann et
374 al., 1989; Shin et al., 2012; Toulotte et al., 2006), however two studies with small sample sizes
375 reported contradictory associations. Cho and Kamen (1998) reported that mean balance times
376 with eyes open were higher in non-fallers compared with fallers, but that no difference was
377 found for the eyes closed condition. Conversely, El-Sobkey et al.(2011) reported a higher odds
378 of falling in those with low balance time with eyes closed and no association with eyes open
379 times. Other variations in balance protocol did not impact greatly on findings; for example,
380 similar associations were found when the following were considered: right or left stance
381 leg(Ansai et al., 2016; Choy et al., 2008; Moreira et al., 2017), better or worse stance leg(Kwan
382 et al., 2011; Shinohara et al., 2020) or when the first or best trial was used (Heitmann et al.,
383 1989).

384 *3.5.3 Results not captured above*

385 Associations between balance and falls identified in five studies could not be included in the
386 syntheses above as they operationalised balance or falls in a non-standard way that limited
387 comparability or they did not provide sufficient study details to interpret the estimates. Further
388 details on these studies are provided in Appendix I. Briefly, a study by Toulotte et al.(2006)
389 provided support for better balance in non-fallers compared with fallers, a study by de
390 Rekeniere et al.(2003) reported no difference in balance between fallers and non-fallers, and
391 the remaining three studies reported inconsistent or uninterpretable findings(Choy et al., 2008;
392 Choy et al., 2007; Ikegami et al., 2019).

393 **4.0 DISCUSSION**

394 *4.1 Main findings*

395 In a systematic review of published studies, we identified 55 papers that had examined the
396 association between one-legged balance performance and fall risk in community-dwelling
397 adults, with the majority of samples aged 65+. Although there was inconsistency in findings,
398 there was some evidence to suggest that non-fallers had better balance times than fallers and
399 that lower one-legged balance time was more strongly associated with increased risk of
400 recurrent falls than any fall. However, studies were often of low quality, had a cross-sectional
401 design and considered unadjusted models only. Many studies assessed balance performance

402 after the fall recall period (e.g. cross-sectional design) and thus reverse causality is likely to
403 explain some of this association. Where adjusted models were presented, results suggested that
404 associations were largely explained by confounders. Additionally, prognostic accuracy of the
405 one-legged test was very poor. Thus, the findings of the review crucially highlight the lack of
406 high-quality empirical evidence to support the use of the one-legged balance test as both a
407 screening tool in clinical settings and as an assessment of fall risk in research settings. This
408 finding has very important implications as it cautions against the premature translation of the
409 one-legged balance test into clinical settings. With low quality and inconsistent evidence, there
410 is an urgent need for better, methodologically robust epidemiological evidence in this area.

411 *4.2 Critical appraisal of studies*

412 Due to considerable between-study heterogeneity in sample characteristics, temporality of
413 associations, and measurement and operationalisation of balance and falls, results should be
414 interpreted with caution. A key challenge in interpreting the findings of included studies is that
415 33 of the 55 papers examined cross-sectional associations between balance performance and
416 falls within the previous 3 to 25 months. As the balance assessment occurred after the fall
417 reporting period, associations identified may, at least partially, be explained by reverse
418 causality. This is plausible as falls have been shown to precipitate mobility impairment,
419 contribute to fear of falling and lead to declining activity levels(Boyd and Stevens, 2009;
420 Stalenhoef et al., 2002); each of which has detrimental effects on balance ability.

421 Another key challenge for synthesis and interpretation of estimates was the fact that the
422 distribution of one-legged balance times was overlooked in many study analyses. Skewed
423 distribution of balance times is common as one-legged balance performance tests are
424 vulnerable to both floor and ceiling effects depending on the sample age and complexity of the
425 protocol(Bergquist et al., 2019; Blodgett et al., 2020b; Choi et al., 2014; Morioka et al., 2012).
426 The most commonly reported estimate (n=24 studies) was the difference in mean balance times
427 between fallers and non-fallers, however this comparison does not meet the key assumption of
428 normality required for a parametric test (i.e. t-test)(Bridge and Sawilowsky, 1999; Vickers,
429 2005). Although we present meta-analyses of these results, the results of the SMD approach
430 could be driven by exceedingly low or high performing individuals, rather than the sample as
431 a whole, and must be interpreted with caution.

432 Less than a third of papers considered confounding. Where studies did adjust for covariates,
433 these adjustments explained most of the associations between balance and falls. No study

434 provided individual stages of adjustment nor considered if covariates acted as confounders or
435 mediators of the balance-fall associations, which is essential to understand the underlying
436 mechanisms of association between balance and falls.

437 **4.3 Potential sources of heterogeneity**

438 There was high heterogeneity between studies in terms of sample characteristics, ascertainment
439 of balance and falls and reporting of results across studies. As such, we were largely unable to
440 examine how balance-falls associations may differ across sample characteristics (e.g. country,
441 sex). For example, only five papers considered sex differences in their analyses(Blain et al.,
442 2021; Ek et al., 2019a; Ek et al., 2019b; Lim et al., 2016; Vellas et al., 1998), despite
443 conceivable sex differences indicated by better one-legged balance in men and greater
444 prevalence of falls in women(Blodgett et al., 2020a; Cooper et al., 2011; Overstall et al., 1977;
445 Peeters et al., 2018; Springer et al., 2007). Similarly, all but one study (Lim et al., 2016)
446 examined associations across the full age range of their sample. Although stratification of the
447 standardised mean difference meta-analysis by mean age of sample (<75, ≥ 75 years) suggested
448 that associations were stronger in younger adults, there remained substantial heterogeneity in
449 the age range of each sample. Further investigation of age differences within the same sample
450 using homogenous protocols is required.

451 Differences in balance testing protocols may also partially explain inconsistent findings. The
452 majority of studies did not state the starting position or the criteria that ended the balance trial,
453 despite important factors such as movement in the arms, legs and eyes that contribute to balance
454 performance(Boström et al., 2018; Scholz et al., 2012). As upper body movement can
455 counteract postural instability despite an unstable centre of gravity, leniency in movement of
456 the arms or stance leg could reduce the reliability and comparability of balance times. Some
457 studies explicitly permitted movement of the legs or arms(Bergland and Wyller, 2004;
458 Heitmann et al., 1989; Sampaio et al., 2013), others ended the trial if there was any
459 movement(Briggs et al., 1989; Choy et al., 2008; Choy et al., 2007; Depasquale and Toscano,
460 2009; El-Sobkey, 2011; Eto and Miyauchi, 2018; Hasegawa et al., 2019; Hashidate et al., 2011;
461 MacRae et al., 1992; Mulasso et al., 2017; Niam and Wee, 1999), while most studies did not
462 provide details. Similarly, several studies instructed participants to focus their eyes on a head-
463 level target(Ansai et al., 2016; El-Sobkey, 2011; Niam and Wee, 1999); this is hypothesised to
464 improve balance performance as visual concentration can improve proprioceptive input(Wulf
465 and Lewthwaite, 2016; Wulf et al., 2001). There are inconsistent reports of test-retest reliability
466 for the one-legged balance test (intraclass correlation coefficient: 0.56-0.94) (Franchignoni et

467 al., 1998; Kammerlind et al., 2005; Lin et al., 2004a; Wolinsky et al., 2005). Selecting the best
468 result, rather than the average time or a comparison of multiple testing conditions, has been
469 recommended to improve reliability(Ponce-González et al., 2014). However, in the studies
470 synthesised in this review, single trials of balance (n=19) were common, while studies using
471 multiple trials had diverse approaches to selecting a balance score for analysis. Other
472 differences in balance protocols include test duration (e.g. ceiling effects), inclusion of
473 individuals who could not do the test (e.g. zero imputation, exclusion, minimum balance time
474 required for inclusion), testing leg (e.g. left or right, dominant or non-dominant) and cut-points
475 (e.g. <1.02s(Thomas and Lane, 2005) vs. 55.4s(Eto and Miyauchi, 2018)).

476 A final source of heterogeneity was the ascertainment of falls. Most studies relied on
477 retrospective, self-reported measures; inaccuracies in retrospective recall of falls are common
478 due to poor recollection and interindividual differences in what constitutes a fall (Ganz et al.,
479 2005; Griffin et al., 2019; Sanders et al., 2015). Longer recall periods can further reduce the
480 accuracy of reporting of falls and in addition may contribute to greater residual
481 confounding(Ganz et al., 2005) due to the complexity of factors that accumulate and contribute
482 to subsequent falls(Nowak and Hubbard, 2009). Conversely, if the follow-up period is too
483 short, there may not be sufficient opportunity for a fall event to occur which could lead to
484 associations being underestimated. For example, two studies had a recall or follow-up period
485 of less than 12 months, both Ansai et al. (2016) and Shimada et al. (2011) found no difference
486 in median balance times in fallers and non-fallers over a 3-month recall period.

487 **4.4 Prognostic accuracy and recurrent falls**

488 Traditional analytical techniques such as mean comparison or regression modelling, commonly
489 used in studies identified in this review, do not assess the predictive ability of the one-legged
490 balance test(Grady and Berkowitz, 2011; Ware, 2006). Of the 7 studies that did report the
491 prognostic accuracy of the test, and the 11 studies in which it could be calculated, findings
492 suggest that one-legged balance performance poorly predicts fall outcomes, with low AUCs
493 and higher specificity than sensitivity (Table 3). This indicates that, if used as a screening tool,
494 one-legged balance performance may not adequately identify those at higher risk of falling.

495 Our synthesis of evidence based on estimates reported in 9 of the 55 included papers suggested
496 that both observational associations and evidence of prognostic accuracy were stronger for
497 recurrent falls than for any fall. This is consistent with previous evidence reporting that
498 individuals who fall one time are more similar to non-fallers than to recurrent or injurious

499 fallers(Delbaere et al., 2010; Lord et al., 1991; Nevitt et al., 1989) and that there are more
500 clearly defined risk factors for recurrent falls(Nevitt et al., 1989; Tinetti and Speechley, 1989).
501 As single falls can commonly occur due to unanticipated environmental hazards, distinct
502 analysis of balance and recurrent falls may better inform overall fall risk. This may also be true
503 for associations between balance and injurious falls, where associations between balance and
504 hospital fall data in a Swedish cohort were robust to adjustment for covariates and follow-up
505 duration(Ek et al., 2019a; Ek et al., 2019b; Welmer et al., 2017). As balance ability may be
506 more consistently associated with recurrent or injurious falls than single falls, allocation of
507 resources to individuals at greater risk of more severe consequences should be considered.

508 ***4.5 Strengths and limitations***

509 This systematic review followed a rigorous protocol with two authors independently
510 identifying eligible papers and extracting relevant data on associations. To our knowledge, this
511 is the first systematic review to focus on the one-legged balance test in relation to fall outcomes;
512 as a result, the number of studies identified is much higher compared with reviews that consider
513 multiple balance tests(Gates et al., 2008; Kozinc et al., 2020; Lusardi et al., 2017; Power et al.,
514 2014). For example, a recent systematic review that examined multiple balance tests in relation
515 to fall risk identified 67 studies, only 14 of which examined one-leg balance tests(Kozinc et
516 al., 2020). Another strength of our review is that publication bias was minimised by including
517 all studies that reported on balance-fall associations even if this was not the main study
518 objective.

519 There are some potential limitations to this review. As only English language articles were
520 included, it is possible that relevant data from non-English languages were missed(Ben Achour
521 Lebib et al., 2006; Hatayama, 2008). Only two meta-analyses could be conducted and we were
522 limited to undertaking narrative syntheses of regression and prognostic estimates due to major
523 heterogeneity between studies in their methods and analytical approaches. Furthermore,
524 publication bias could only be formally assessed using the Egger test and funnel plots for the
525 17 studies included in the SMD meta-analysis. While comparisons of means need to be
526 interpreted with great caution given the non-parametric distribution of balance times, we
527 decided to report the SMD meta-analysis with caveats as it was the most commonly presented
528 association. Finally, we focused on balance time in relation to fall risk and did not consider
529 other potentially relevant measures of one-legged balance such as postural sway.

530 ***4.6 Implications and future steps***

531 Although the one-legged balance test has been recommended as a screening tool for falls in
532 clinical settings outcomes(Kozinc et al., 2020; Michikawa et al., 2009; Nickelston, 2014), we
533 have not found consistent evidence to support this. The results of our review highlight the need
534 for caution and suggest limitations to the use of the one-legged balance test for this purpose in
535 both clinical and research settings. Many studies scored poorly on the Newcastle-Ottawa risk
536 of bias scale (see Appendix B), due to inadequate reporting of balance and fall ascertainment,
537 temporality, low comparability of adjusted estimates and statistical analyses. High-quality
538 longitudinal studies that measure one-legged balance performance before fall reporting periods
539 is crucial to establish temporality of association and minimise the potential impact of reverse
540 causality.

541 Despite the poor quality of most studies, associations between one-legged balance test and risk
542 of recurrent or injurious falls may be an important avenue of further research. For example,
543 there were robust associations between one-legged balance time and injurious fall risk in the
544 SNAC-K study; whether this is due to the nature of injurious falls or the high quality of cohort
545 data used is not clear. Further investigation of various fall outcomes within the same study
546 sample is necessary to inform translation of this research. If these associations remain,
547 prevention efforts could improve efficiency by targeting those at risk of recurrent or injurious
548 fall outcomes(Peeters et al., 2007).

549 Few studies examined if associations between balance and falls differed between men and
550 women or at different ages, which is a key consideration when translating findings to clinical
551 settings. One promising avenue for further exploration is the indication that one-legged balance
552 with eyes closed, a more challenging test, may better identify fall risk in younger individuals,
553 while the eyes open test may be a more appropriate test for older adults. This is supported by
554 findings from Cho and Kamen(1998) and El-Sobkey(2011), which reported that balance with
555 eyes closed but not opened was associated with falls in younger adults (mean age: 66.5) and
556 that balance with eyes open but not closed was associated with falls in older adults (mean age
557 74.5); replication of these analyses in larger, population-representative studies is required.
558 Stratification of the meta-analysis by age (<75, ≥ 75 years) suggested that associations were
559 stronger in younger adults. Although the one-legged balance test is commonly used in those
560 aged 65+, there may be a floor effect at older ages, particularly for those who may be at highest
561 risk of falling. This may partially explain why one-legged balance had poor prognostic
562 accuracy in predicting falls.

563 Although our review identifies the most common elements of one-legged balance measurement
564 protocols, further work is needed to identify and standardise a protocol for use in research and
565 clinical settings. Factors to consider include number of trials, leg choice, trial duration,
566 continuous timing, body position of arms and raised leg, and criteria for stopping the timed
567 trial. Moving forward, it is equally crucial that all studies who report on one-legged balance
568 tests provide details of the protocol used to better facilitate standardisation and comparison
569 across studies.

570 A key advantage of the one-legged balance test is its ability to isolate balance ability, in contrast
571 to other measures such as the time-up-and-go, walking speed or chair rise. However,
572 attenuation of estimates after adjustment suggests that other non-balance factors may better
573 explain fall risk. For example, Power et al. (2014) suggested that there was strong evidence
574 that tests that incorporated balance and mobility (e.g. Timed Up and Go, sit to stand or walking
575 speed assessment) could predict falls, with weaker evidence for measures of standing balance
576 and functional reach. While there is utility in examining isolated measures of balance to
577 understand the mechanism of association with falls (Montero-Odasso and Speechley, 2018), a
578 combined risk prediction tool that incorporates balance, mobility and fall history may be
579 preferable. Fall risk screening guidelines have recommended a two-factor approach of fall
580 history and a measure of balance or gait ability (American Geriatrics Society, 2001). If no
581 single test is sufficient to meaningfully predict falls (Gates et al., 2008; Lusardi et al., 2017),
582 further research is needed to create an accurate multifactorial screening tool.”

583 **CONCLUSIONS**

584 This systematic review identified 55 papers from 51 study samples that examined the
585 association between one-legged balance performance and fall risk. Study quality was
586 consistently low across papers, limiting our ability to establish any clear conclusions. Despite
587 previous advocacy for the one-legged balance test as a feasible and inexpensive screening tool,
588 we found limited support for this, particularly in studies that temporally distinguished one-
589 legged balance and falls (i.e. longitudinal design). As the global population continues to age,
590 the absence of robust empirical evidence on the association between one-legged balance and
591 falls highlights the need to prioritise high quality studies in this area. Our review highlights
592 crucial gaps in the existing literature that must be addressed to inform translation of balance
593 assessments into effective screening tools to help address the rising prevalence of falls in an
594 ageing population.

595 **Funding:** This work was supported by the Canadian Institutes of Health Research (FDSA),
596 the Canadian Centennial Scholarship Fund, the Medical Research Council (MC_UU_00019/1
597 Theme 1: Cohorts and Data Collection to NSHD; MC_UU_12019/1, MC_UU_12019/2 and
598 MC_UU_12019/4) and the Economic and Social Research Council (ES/K000357/1)

599

600 **REFERENCES**

- 601 American Geriatrics Society, B.G.S., and American Academy of Orthopaedic Surgeons Panel
602 on Falls Prevention, 2001. Guideline for the prevention of falls in older persons. *J Am*
603 *Geriatr Soc* 49, 664-672.
- 604 Andresen, E.M., Wolinsky, F.D., Miller, J.P., Wilson, M.-M.G., Malmstrom, T.K., Miller,
605 D.K., 2006. Cross-sectional and longitudinal risk factors for falls, fear of falling, and falls
606 efficacy in a cohort of middle-aged African Americans. *The Gerontologist* 46, 249-257.
- 607 Ansai, J.H., Aurichio, T.R., Rebelatto, J.R., 2016. Relationship between balance and dual
608 task walking in the very elderly. *Geriatrics & gerontology international* 16, 89-94.
- 609 Arai, T., Fujita, H., Maruya, K., Morita, Y., Asahi, R., Ishibashi, H., 2020. The one-leg
610 portion of the Stand-Up Test predicts fall risk in aged individuals: A prospective cohort
611 study. *J Orthop Sci* 25, 688-692.
- 612 Balduzzi, S., Rücker, G., Schwarzer, G., 2019. How to perform a meta-analysis with R: a
613 practical tutorial. *Evidence-Based Mental Health*, 153-160.
- 614 Barry, E., Galvin, R., Keogh, C., Horgan, F., Fahey, T., 2014. Is the timed up and go test a
615 useful predictor of risk of falls in community dwelling older adults: a systematic review
616 and meta- analysis. *BMC Geriatr* 14.
- 617 Beauchet, O., Rossat, A., Bongue, B., Dupre, C., Colvez, A., Fantino, B., Fantino, B., 2010.
618 Change in arm position during one-leg balance test: a predictor of recurrent falls in
619 community-dwelling older adults. *J Am Geriatr Soc* 58, 1598-1600.
- 620 Ben Achour Lebib, S., Missaoui, B., Miri, I., Ben Salah, F.Z., Dziri, C., 2006. Rôle du
621 Neurocom Balance Master dans l'évaluation des troubles de l'équilibre et du risque de
622 chute chez le sujet âgé. *Ann Readapt Med Phys* 49, 210-217.
- 623 Bergland, A., Wyller, T.B., 2004. Risk factors for serious fall related injury in elderly women
624 living at home. *Inj Prev* 10, 308-313.
- 625 Bergquist, R., Weber, M., Schwenk, M., al, e., 2019. Performance-based clinical tests of
626 balance and muscle strength used in young seniors: a systematic literature review. *BMC*
627 *Geriatr* 19, 9.
- 628 Blain, H., Gamon, L., Aliaga, B., Soriteau, L., Raffort, N., Miot, S., Picot, M.C., Bousquet,
629 J., Bernard, P.L., 2021. Self-reported fatigue: A significant risk factor for falling in older
630 women and men. *Exp Gerontol* 143, 111154.
- 631 Blodgett, J.M., Cooper, R., Davis, D.H.J., Kuh, D., Hardy, R., 2020a. Associations between
632 factors across life and balance ability in mid and later life: evidence from a British birth
633 cohort study. *Frontiers in Sports and Active Living* 2.
- 634 Blodgett, J.M., Cooper, R., Davis, D.H.J., Kuh, D., Hardy, R., 2020b. Investigating
635 bidirectional associations between verbal memory and one-legged balance performance in
636 mid and later life. *JGMS* [submitted].
- 637 Blodgett, J.M., Cooper, R., Mills, R., Ventre, J., Hardy, R., 2020c. One-legged balance as a
638 risk factor for falls: a systematic review PROSPERO: CRD42020160413.
- 639 Bohannon, R.W., 2006. Single limb stance times - A descriptive meta-analysis of data from
640 individuals at least 60 years of age. *Topics in Geriatric Rehabilitation* 22, 70-77.
- 641 Bongue, B., Dupre, C., Beauchet, O., Rossat, A., Fantino, B., Colvez, A., 2011. A screening
642 tool with five risk factors was developed for fall-risk prediction in community-dwelling
643 elderly. *Journal of clinical epidemiology* 64, 1152-1160.
- 644 Boström, K.J., Dirksen, T., Zentgraf, K., Wagner, H., 2018. The Contribution of Upper Body
645 Movements to Dynamic Balance Regulation during Challenged Locomotion. *Frontiers in*
646 *Human Neuroscience* 12.
- 647 Boyd, R., Stevens, J.A., 2009. Falls and fear of falling: burden, beliefs and behaviours. *Age*
648 *and Ageing* 38, 423-428.

649 Bridge, P.D., Sawilowsky, S.S., 1999. Increasing physicians' awareness of the impact of
650 statistics on research outcomes: comparative power of the t-test and and Wilcoxon Rank-
651 Sum test in small samples applied research. *J Clin Epidemiol* 52, 229-235.

652 Briggs, R.C., Gossman, M.R., Birch, R., Drews, J.E., Shaddeau, S.A., 1989. Balance
653 performance among noninstitutionalized elderly women. *Phys Ther* 69, 748-756.

654 Buatois, S., Gueguen, R., Gauchard, G.C., Benetos, A., Perrin, P.P., 2006. Posturography and
655 risk of recurrent falls in healthy non-institutionalized persons aged over 65. *Gerontology*
656 52, 345-352.

657 Buatois, S., Perret-Guillaume, C., Gueguen, R., Miget, P., Vancon, G., Perrin, P., Benetos,
658 A., 2010. A simple clinical scale to stratify risk of recurrent falls in community-dwelling
659 adults aged 65 years and older. *Phys Ther* 90, 550-560.

660 Cho, C.Y., Kamen, G., 1998. Detecting balance deficits in frequent fallers using clinical and
661 quantitative evaluation tools. *Journal of the American Geriatrics Society* 46, 426-430.

662 Choi, Y.M., Dobson, F., Martin, J., Bennell, K.L., Hinman, R.S., 2014. Interrater and
663 intrarater reliability of common clinical standing balance tests for people with hip
664 osteoarthritis. *Phys Ther* 94, 696-704.

665 Choy, N.L., Brauer, S., Nitz, J., 2008. Linking stability to demographics, strength and
666 sensory system function in women over 40 to support pre-emptive preventive intervention.
667 *Climacteric* 11, 144-154.

668 Choy, N.L.L., Brauer, S.G., Nitz, J.C., 2007. Timed stance performances reflect differences
669 in age, prevalence of comorbidities, medication use, fall history and activity level: Early
670 screening for balance loss is indicated. *Australasian Journal on Ageing* 26, 29-34.

671 Cooper, R., Hardy, R., Aihie Sayer, A., Ben-Shlomo, Y., Birnie, K., Cooper, C., Craig, L.,
672 Deary, I.J., Demakakos, P., Gallacher, J., McNeill, G., Martin, R.M., Starr, J.M., Steptoe,
673 A., Kuh, D., team, H.A.s., 2011. Age and gender differences in physical capability levels
674 from mid-life onwards: the harmonisation and meta-analysis of data from eight UK cohort
675 studies. *PLoS One* 6, e27899.

676 Crenshaw, J.R., Bernhardt, K.A., Atkinson, E.J., Achenbach, S.J., Khosla, S., Amin, S.,
677 Kaufman, K.R., 2020. Posterior single-stepping thresholds are prospectively related to
678 falls in older women. *Aging Clin Exp Res* 32, 2507-2515.

679 de Rekeneire, N., Visser, M., Peila, R., Nevitt, M.C., Cauley, J.A., Tylavsky, F.A.,
680 Simonsick, E.M., Harris, T.B., 2003. Is a fall just a fall: correlates of falling in healthy
681 older persons. The Health, Aging and Body Composition Study. *J Am Geriatr Soc* 51,
682 841-846.

683 Delbaere, K., Close, J.C., Heim, J., Sachdev, P.S., Brodaty, H., Slavin, M.J., Kochan, N.A.,
684 Lord, S.R., 2010. A multifactorial approach to understanding fall risk in older people. *J*
685 *Am Geriatr Soc* 58, 1679-1685.

686 Dellinger, A., 2017. Older Adult Falls: Effective Approaches to Prevention. *Curr Trauma*
687 *Rep* 3, 118-123.

688 Depasquale, L., Toscano, L., 2009. The Spring Scale Test: a reliable and valid tool for
689 explaining fall history. *Journal of geriatric physical therapy (2001)* 32, 159-167.

690 Ek, S., Rizzuto, D., Calderon-Larranaga, A., Franzen, E., Xu, W., Welmer, A.K., 2019a.
691 Predicting First-Time Injurious Falls in Older Men and Women Living in the Community:
692 Development of the First Injurious Fall Screening Tool. *Journal of the American Medical*
693 *Directors Association* 20, 1163-1168.e1163.

694 Ek, S., Rizzuto, D., Fratiglioni, L., Calderon-Larranaga, A., Johnell, K., Sjoberg, L., Xu, W.,
695 Welmer, A.-K., 2019b. Risk factors for injurious falls in older adults: the role of sex and
696 length of follow-up. *J Am Geriatr Soc* 67, 246-253.

697 El-Sobkey, S.B., 2011. Balance performance of community-dwelling older people. *Saudi*
698 *medical journal* 32, 283-287.

699 Eto, M., Miyauchi, S., 2018. Relationship between occlusal force and falls among
700 community-dwelling elderly in Japan: a cross-sectional correlative study. *BMC geriatrics*
701 18, 111.

702 Florence, C.S., Bergen, G., Atherly, A., Burns, E., Stevens, J., Drake, C., 2018. Medical
703 Costs of Fatal and Nonfatal Falls in Older Adults. *J Am Geriatr Soc* 66, 693-698.

704 Franchignoni, F., Tesio, L., Martino, M.T., Ricupero, C., 1998. Reliability of four simple,
705 quantitative tests of balance and mobility in healthy elderly females. *Aging Clinical and*
706 *Experimental Research* 10, 26-31.

707 Ganz, D.A., Bao, Y., Shekelle, P.G., Rubenstein, L.Z., 2007. Will my patient fall? *JAMA*
708 297, 77-86.

709 Ganz, D.A., Higashi, T., Rubenstein, L.Z., 2005. Monitoring falls in cohort studies of
710 community-dwelling older people: effect of the recall interval. *J Am Geriatr Soc* 53, 2190-
711 2194.

712 Gates, S., Smith, L.A., Fisher, J.D., Lamb, S.E., 2008. Systematic review of accuracy of
713 screening instruments for predicting fall risk among independently living older adults. *The*
714 *Journal of Rehabilitation Research and Development* 45, 1105.

715 Gerdhem, P., Ringsberg, K.A.M., Akesson, K., Obrant, K.J., 2005. Clinical history and
716 biologic age predicted falls better than objective functional tests. *Journal of clinical*
717 *epidemiology* 58, 226-232.

718 Grady, D., Berkowitz, S.A., 2011. Why is a good clinical prediction rule so hard to find?
719 *Arch Intern Med* 171, 1701-1702.

720 Griffin, J., Lall, R., Bruce, J., Withers, E., Finnegan, S., Lamb, S.E., Underwood, M., Martin,
721 F., Yardley, L., Skelton, D., Willett, K., Eldridge, S., Slowther, A.-M., Duggan, S.,
722 Hennings, S., Mant, R., Rai, R., Turner, C., Andrews, A., Fearn, R., Walker, N., Potter, R.,
723 Hulme, C., Bojke, C., Longo, R., Westacott, K., Ralhan, S., Sheridan, R., Treml, J., Riglin,
724 J., Gordjin, H., Dutta, R., Burns, J., Shaw, F., Davison, J., Willis, A., Muthiah, C., Adjei,
725 H., 2019. Comparison of alternative falls data collection methods in the Prevention of
726 Falls Injury Trial (PreFIT). *Journal of Clinical Epidemiology* 106, 32-40.

727 Hasegawa, Y., Horii, N., Sakuramoto-Sadakane, A., Nagai, K., Ono, T., Sawada, T.,
728 Shinmura, K., Kishimoto, H., 2019. Is a history of falling related to oral function? A cross-
729 sectional survey of elderly subjects in rural Japan. *International Journal of Environmental*
730 *Research and Public Health* 16.

731 Hashidate, H., Shimada, H., Shiomi, T., Sasamoto, N., 2011. Usefulness of the subjective risk
732 rating of specific tasks for falls in frail elderly people. *Journal of Physical Therapy*
733 *Science* 23, 519-524.

734 Hatayama, T.N., M Une, H Yoshitake, Y Kimura, Y Momose, Y Kai, Y Suwa, M
735 Kumagai, S, 2008. The association between incidence of falls and physical fitness in
736 community- dwelling elderly. *Japanese Journal of physical fitness and sports medicine* 57,
737 503-510.

738 Heitmann, D.K., Gossman, M.R., Shaddeau, S.A., Jackson, J.R., D.K, H., M.R, G., S.A, S.,
739 Dk, H., Mr, G., Sa, S., Jr, J., 1989. Balance performance and step width in
740 noninstitutionalized, elderly, female fallers and nonfallers. *Physical Therapy* 69, 923-931.

741 Higgins, J.P., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003. Measuring inconsistency in
742 meta-analyses. *BMJ* 327, 557-560.

743 Hopewell, S., Adedire, O., Copsey, B.J., Boniface, G.J., Sherrington, C., Clemson, L., Close,
744 J.C., Lamb, S.E., 2018. Multifactorial and multiple component interventions for
745 preventing falls in older people living in the community. *Cochrane Database Syst Rev* 7,
746 Cd012221.

- 747 Ikegami, S., Takahashi, J., Uehara, M., Tokida, R., Nishimura, H., Sakai, A., Kato, H., 2019.
748 Physical performance reflects cognitive function, fall risk, and quality of life in
749 community-dwelling older people. *Scientific Reports* 9, 12242-12242.
- 750 Jalali, M.M., Gerami, H., Heidarzadeh, A., Soleimani, R., 2015. Balance performance in
751 older adults and its relationship with falling. *Aging clinical and experimental research* 27,
752 287-296.
- 753 James, S.L., Lucchesi, L.R., Bisignano, C., 2020. The global burden of falls: global, regional
754 and national estimates of morbidity and mortality from the Global Burden of Disease
755 Study 2017 *Inj Prev* 26, 3-11.
- 756 Jonsson, E., Seiger, A., Hirschfeld, H., 2004. One-leg stance in healthy young and elderly
757 adults: a measure of postural steadiness? *Clin Biomech (Bristol, Avon)* 19, 688-694.
- 758 Kammerlind, A.S., Bergquist Larsson, P., Ledin, T., Skargren, E., 2005. Reliability of
759 clinical balance tests and subjective ratings in dizziness and disequilibrium. *Advances in*
760 *Physiotherapy* 7, 96-107.
- 761 Kozinc, Ž., Löfler, S., Hofer, C., Carraro, U., Šarabon, N., 2020. Diagnostic balance tests for
762 assessing risk of falls and distinguishing older adult fallers and non-fallers: a systematic
763 review with meta-analysis. *Diagnostics (Basel)* 10, 667.
- 764 Kwan, M.M.-S., Lin, S.-I., Chen, C.-H., Close, J.C., Lord, S.R., 2011. Minimal chair height
765 standing ability is independently associated with falls in Taiwanese older people. *Archives*
766 *of physical medicine and rehabilitation* 92, 1080-1085.
- 767 Lakens, D., 2013. Calculating and reporting effect sizes to facilitate cumulative science: a
768 practical primer for t-tests and ANOVAs. *Frontiers in Psychology* 4, 863.
- 769 Li, F., He, H., 2018. Assessing the Accuracy of Diagnostic Tests. *Shanghai archives of*
770 *psychiatry* 30, 207-212.
- 771 Lim, Y., Kim, K., Ko, S.-H., Cho, K., Jang, E.-H., Lee, S.-H., Lim, D.J., Baek, K.H., Ha, H.-
772 S., Park, M.S., Yim, H.-W., Lee, W.-C., Yoon, K.-H., Son, H.Y., Oh, K.W., Kang, M.-I.,
773 2016. Gender- and age-group-specific associations between physical performance and
774 bone mineral density, falls, and osteoporotic fractures in Koreans: the Chungju Metabolic
775 Disease Cohort study. *Journal of bone and mineral metabolism* 34, 336-346.
- 776 Lima, C.A., Ricci, N.A., Nogueira, E.C., Perracini, M.R., 2018. The Berg Balance Scale as a
777 clinical screening tool to predict fall risk in older adults: a systematic review.
778 *Physiotherapy* 104, 383-394.
- 779 Lin, M.-R., Hwang, H.-F., Hu, M.-H., Wu, H.-D.I., Wang, Y.-W., Huang, F.-C., 2004a.
780 Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and
781 Tinetti balance measures in community-dwelling older people. *Journal of the American*
782 *Geriatrics Society* 52, 1343-1348.
- 783 Lin, M.R., Hwang, H.F., Hu, M.H., Wu, H.D., Wang, Y.W., Huang, F.C., 2004b.
784 Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and
785 Tinetti balance measures in community-dwelling older people. *J Am Geriatr Soc* 52, 1343-
786 1348.
- 787 Lord, S.R., Clark, R.D., Webster, I.W., 1991. Physiological factors associated with falls in an
788 elderly population. *J Am Geriatr Soc* 39, 1194-1200.
- 789 Lusardi, M.M., Fritz, S., Middleton, A., Allison, L., Wingood, M., Phillips, E., Criss, M.,
790 Verma, S., Osborne, J., Chui, K.K., 2017. Determining risk of falls in community dwelling
791 older adults: a systematic review and meta-analysis using posttest probability. *J Geriatr*
792 *Phys Ther* 40, 1-36.
- 793 Ma, J., Liu, W., Hunter, A., *et al*, 2008. Performing meta-analysis with incomplete statistical
794 information in clinical trials. *BMC Med Res Methodol* 8.

795 MacRae, P.G., Lacourse, M., Moldavon, R., 1992. Physical performance measures that
796 predict faller status in community- dwelling older adults. *Journal of Orthopaedic and*
797 *Sports Physical Therapy* 16, 123-128.

798 Mahoney, J.R., Cotton, K., Verghese, J., 2019. Multisensory Integration Predicts Balance and
799 Falls in Older Adults. *The journals of gerontology Series A, Biological sciences and*
800 *medical sciences.* 74, 1429-1435.

801 Mancini, M., Horak, F.B., 2010. The relevance of clinical balance assessment tools to
802 differentiate balance deficits. *Eur J Phys Rehabil Med* 46, 239-248.

803 McGrath, S., Sohn, H., Steele, R., Benedetti, A., 2020. Meta-analysis of the difference of
804 medians. *Biometrical Journal* 62, 69 – 98.

805 Michikawa, T., Nishiwaki, Y., Takebayashi, T., Toyama, Y., 2009. One-leg standing test for
806 elderly populations. *J Orthop Sci* 14, 675-685.

807 Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., The, P.G., 2009. Preferred Reporting
808 Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 6.

809 Montero-Odasso, M., Speechley, M., 2018. Falls in cognitively impaired older adults:
810 implications for risk sssessment and prevention. *J Am Geriatr Soc* 66, 367-375.

811 Moore, M., Barker, K., 2017. The validity and reliability of the four square step test in
812 different adult populations: a systematic review. *Syst Rev* 6, 187.

813 Moreira, M.N., Bilton, T.L., Dias, R.C., Ferriolli, E., Perracini, M.R., 2017. What are the
814 main physical functioning factors associated with falls among older people with different
815 perceived fall risk? *Physiother Res Int* 22, e1664.

816 Morioka, S., Fukumoto, T., Hiyamizu, M., Matsuo, A., Takebayashi, H., Miyamoto, K.,
817 2012. Changes in the equilibrium of standing on one leg at various life stages. *Curr*
818 *Gerontol Geriatr Res* 2012, 516283.

819 Muir, S.W., Berg, K., Chesworth, B., Klar, N., Speechley, M., 2010. Balance impairment as a
820 risk factor for falls in community-dwelling older adults who are high functioning: a
821 prospective study. *Physical Therapy* 90, 338-347.

822 Mulasso, A., Roppolo, M., Gobbens, R.J., Rabaglietti, E., 2017. Mobility, balance and frailty
823 in community-dwelling older adults: What is the best 1-year predictor of falls? *Geriatrics*
824 *& Gerontology International* 17, 1463-1469.

825 Nahm, F.S., 2016. Nonparametric statistical tests for the continuous data: the basic concept
826 and the practical use. *Korean J Anesthesiol* 69, 8-14.

827 Nevitt, M.C., Cummings, S.R., Kidd, S., Black, D., 1989. Risk factors for recurrent
828 nonsyncopal falls. A prospective study. *JAMA* 261, 2663-2668.

829 Niam, S., Wee, S.K., 1999. Relationship of unipedal stance time, age and falls in healthy
830 Asian elderly. *Physiotherapy Singapore* 2, 124-127.

831 NICE guideline, 2013. Falls in older people: assessing risk and prevention, in: [CG161], C.g.
832 (Ed.). Accessed July 2020 at
833 <https://www.nice.org.uk/guidance/CG161/chapter/introduction>.

834 Nickelston, P., 2014. Why You Should Include the Single-Leg Stance Test in Every Patient
835 Assessment. *Dynamic Chiropractic* 32, 8-14.

836 No author, 1987. The prevention of falls in later life. A report of the Kellogg International
837 Work Group on the Prevention of Falls by the Elderly. *Dan Med Bull* 34, 1-24.

838 Nowak, A., Hubbard, R.E., 2009. Falls and frailty: lessons from complex systems. *Journal of*
839 *the Royal Society of Medicine* 102, 98-102.

840 Okubo, Y., Schoene, D., Caetano, M.J., Pliner, E.M., Osuka, Y., Toson, B., Lord, S.R., 2021.
841 Stepping impairment and falls in older adults: A systematic review and meta-analysis of
842 volitional and reactive step tests. *Ageing Research Reviews* 66, 101238.

843 Ouzzani, M., Hammady, H., Fedorowicz, Z., Elmagarmid, A., 2016. Rayyan—a web and
844 mobile app for systematic reviews. *Syst Rev* 5.

- 845 Overstall, P.W., Exton-Smith, A.N., Imms, F.J., Johnson, A.L., 1977. Falls in the elderly
846 related to postural imbalance. *BMJ*, 261-264.
- 847 Parikh, R., Mathai, A., Parikh, S., Chandra Sekhar, G., Thomas, R., 2008. Understanding and
848 using sensitivity, specificity and predictive values. *Indian journal of ophthalmology* 56,
849 45-50.
- 850 Park, K., Yang, M., Yoo, T.-g., Kim, S.-h., 2020. One-Leg Standing and Y-Balance Test
851 Performance in Elderly Fallers and Nonfallers. *Topics in Geriatric Rehabilitation* 36, 92-
852 96.
- 853 Peeters, G., Cooper, R., Tooth, L., van Schoor, N.M., Kenny, R.A., 2019. A comprehensive
854 assessment of risk factors for falls in middle-aged adults: co-ordinated analyses of cohort
855 studies in four countries. *Osteoporos Int*.
- 856 Peeters, G., van Schoor, N.M., Cooper, R., Tooth, L., Kenny, R.A., 2018. Should prevention
857 of falls start earlier? Co-ordinated analyses of harmonised data on falls in middle-aged
858 adults across four population-based cohort studies. *PLoS One* 13, e0201989.
- 859 Peeters, G.M., de Vries, O.J., Elders, P.J., Pluijm, S.M., Bouter, L.M., Lips, P., 2007.
860 Prevention of fall incidents in patients with a high risk of falling: design of a randomised
861 controlled trial with an economic evaluation of the effect of multidisciplinary transmurial
862 care. *BMC Geriatr* 7, 15.
- 863 Ponce-González, J.G., Sanchis-Moysi, J., González-Henriquez, J.J., Arteaga-Ortiz, R.,
864 Calbet, J.A., Dorado, C., 2014. A reliable unipedal stance test for the assessment of
865 balance using a force platform. *J Sports Med Phys Fitness* 54, 108-117.
- 866 Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., Britten, N., 2006.
867 Guidance on the Conduct of Narrative Synthesis in Systematic Reviews, A Product
868 from the ESRC Methods Programme. Version 1.
- 869 Porto, J.M., Iosimuta, N.C.R., Freire Júnior, R.C., Braghin, R.M.B., Leitner, É., Freitas, L.G.,
870 de Abreu, D.C.C., 2020. Risk factors for future falls among community-dwelling older
871 adults without a fall in the previous year: A prospective one-year longitudinal study. *Arch*
872 *Gerontol Geriatr* 91, 104161.
- 873 Power, V., Van De Ven, P., Nelson, J., Clifford, A.M., 2014. Predicting falls in community-
874 dwelling older adults: a systematic review of task performance-based assessment tools.
875 *Physiotherapy Practice* 35, 3-15.
- 876 Rohatgi, A., 2020. WebPlotDigitalizer: HTML5 based online tool to extract numerical data
877 from plot images. Version 4.3., p. Accessed [http:// arohatgi.info/WebPlotDigitizer/app/](http://arohatgi.info/WebPlotDigitizer/app/) in
878 June 2020.
- 879 Rosa, M.V., Perracini, M.R., Ricci, N.A., 2019. Usefulness, assessment and normative data
880 of the Functional Reach Test in older adults: A systematic review and meta-analysis. *Arch*
881 *Gerontol Geriatr* 81, 149-170.
- 882 Rossat, A., Fantino, B., Bongue, B., Colvez, A., Nitenberg, C., Annweiler, C., Beauchet, O.,
883 2010. Association between benzodiazepines and recurrent falls: A cross-sectional elderly
884 population-based study. *Journal of Nutrition, Health and Aging*, 1-6.
- 885 Sampaio, R.A.C., Sampaio, P.Y.S., Yamada, M., Ogita, M., Matsudo, S.M.M., Raso, V.,
886 Tsuboyama, T., Arai, H., 2013. Factors associated with falls in active older adults in Japan
887 and Brazil. *Journal of Clinical Gerontology and Geriatrics* 4, 89-92.
- 888 Sanders, K.M., Stuart, A.L., Scott, D., Kotowicz, M.A., Nicholson, G.C., 2015. Validity of
889 12-Month Falls Recall in Community-Dwelling Older Women Participating in a Clinical
890 Trial. *Int J Endocrinol* 2015, 210527.
- 891 Scholz, J.P., Park, E., Jeka, J.J., Schöner, G., Kiemel, T., 2012. How visual information links
892 to multijoint coordination during quiet standing. *Exp Brain Res* 222, 229-239.

893 Sherrington, C., Fairhall, N.J., Wallbank, G.K., Tiedemann, A., Michaleff, Z.A., Howard, K.,
894 Clemson, L., Hopewell, S., Lamb, S.E., 2019. Exercise for preventing falls in older people
895 living in the community. *Cochrane Database Syst Rev* 1, Cd012424.

896 Shimada, H., Suzukawa, M., Tiedemann, A., Kobayashi, K., Yoshida, H., Suzuki, T., 2009.
897 Which neuromuscular or cognitive test is the optimal screening tool to predict falls in frail
898 community-dwelling older people? *Gerontology* 55, 532-538.

899 Shimada, H., Tiedemann, A., Lord, S.R., Suzukawa, M., Makizako, H., Kobayashi, K.,
900 Suzuki, T., 2011. Physical factors underlying the association between lower walking
901 performance and falls in older people: a structural equation model. *Archives of*
902 *gerontology and geriatrics* 53, 131-134.

903 Shin, K.R., Kang, Y., Jung, D., Kim, M., Lee, E., 2012. A Comparative Study on Physical
904 Function Test between Faller Group and Nonfaller Group among Community-Dwelling
905 Elderly. *Asian nursing research* 6, 42-48.

906 Shinohara, T., Saida, K., Miyata, K., 2020. Ability of the Brief-Balance Evaluation Systems
907 Test to evaluate balance deficits in community-dwelling older adults: a cross-sectional
908 study. *Physiother Theory Pract*, 1-8.

909 Soriano, T.A., DeCherrie, L.V., Thomas, D.C., 2007. Falls in the community-dwelling older
910 adult: a review for primary-care providers. *Clin Interv Aging* 2, 545-554.

911 Springer, B.A., Marin, R., Cyhan, T., Roberts, H., Gill, N.W., 2007. Normative values for the
912 unipedal stance test with eyes open and closed. *Journal of Geriatric Physical Therapy* 30,
913 8-15.

914 Stalenhoef, P.A., Diederiks, J.P., Knottnerus, J.A., Kester, A.D., Crebolder, H.F., 2002. A
915 risk model for the prediction of recurrent falls in community-dwelling elderly: a
916 prospective cohort study. *J Clin Epidemiol* 55, 1088-1094.

917 Sterne, J.A., Egger, M., 2005. Regression Methods to Detect Publication and Other Bias in
918 Meta-Analysis, *Publication Bias in Meta-Analysis*, pp. 99-110.

919 Swanenburg, J., Nevzati, A., Mittaz Hager, A.G., de Bruin, E.D., Klipstein, A., 2013. The
920 maximal width of the base of support (BSW): clinical applicability and reliability of a
921 preferred-standing test for measuring the risk of falling. *Archives of gerontology and*
922 *geriatrics* 57, 204-210.

923 Thomas, J.I., Lane, J.V., 2005. A pilot study to explore the predictive validity of 4 measures
924 of falls risk in frail elderly patients. *Arch Phys Med Rehabil* 86, 1636-1640.

925 Tinetti, M.E., Speechley, M., 1989. Prevention of falls among the elderly. *N Engl J Med* 320,
926 1055-1059.

927 Tinetti, M.E., Speechley, M., Ginter, S.F., 1988. Risk factors for falls amongst elderly
928 persons living in the community. *New England Journal of Medicine* 319, 1701-1707.

929 Toulotte, C., Thevenon, A., Watelain, E., Fabre, C., 2006. Identification of healthy elderly
930 fallers and non-fallers by gait analysis under dual-task conditions. *Clinical rehabilitation*
931 20, 269-276.

932 Ungar, A., Rafanelli, M., Iacomelli, I., Brunetti, M.A., Ceccofiglio, A., Tesi, F., Marchionni,
933 N., 2013. Fall prevention in the elderly. *Clin Cases Miner Bone Metab* 10, 91-95.

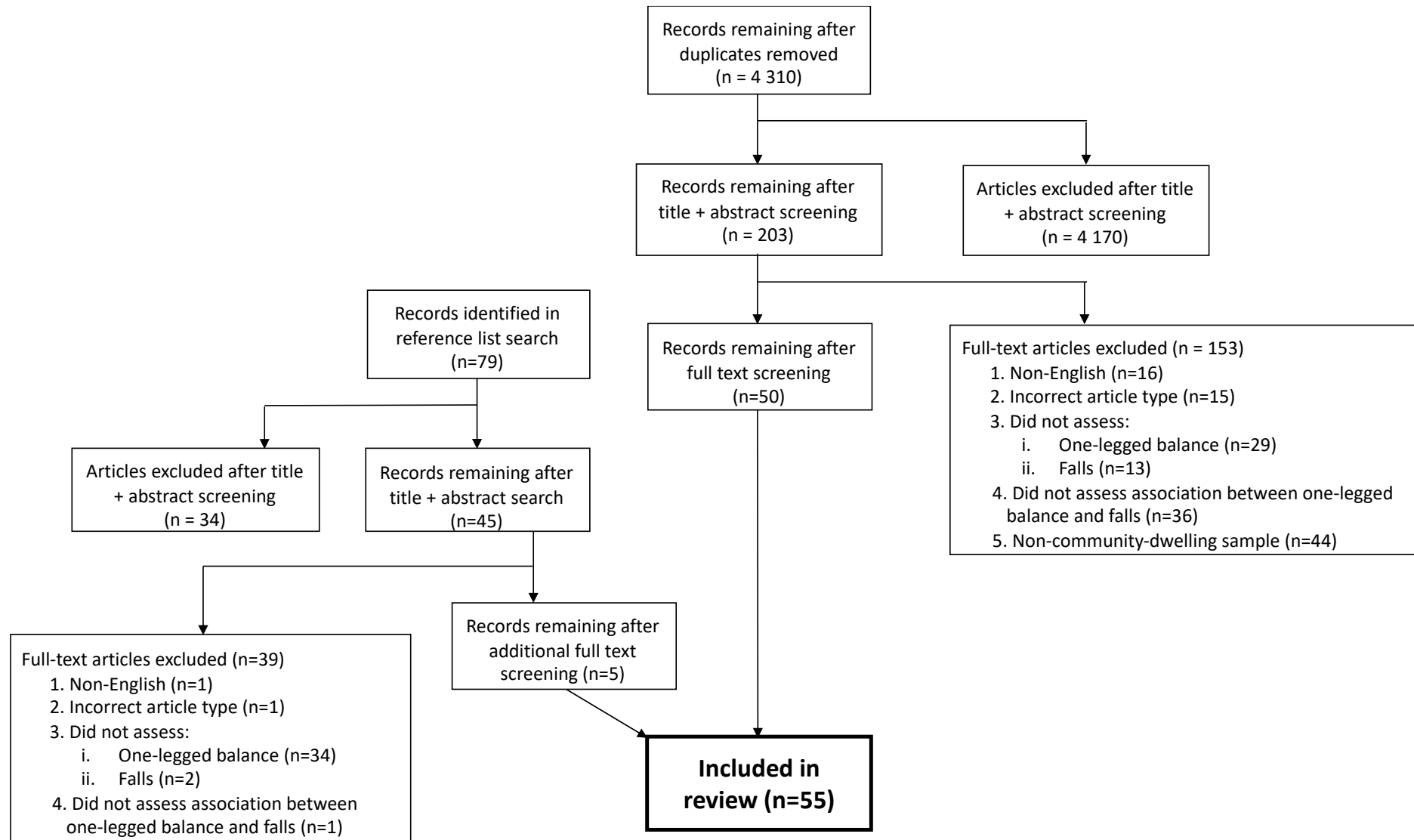
934 Vellas, B.J., Wayne, S.J., Garry, P.J., Baumgartner, R.N., 1998. A two-year longitudinal
935 study of falls in 482 community-dwelling elderly adults. *The journals of gerontology.*
936 *Series A, Biological sciences and medical sciences* 53, M264-274.

937 Vellas, B.J., Wayne, S.J., Romero, L., Baumgartner, R.N., Rubenstein, L.Z., Garry, P.J.,
938 1997. One-leg balance is an important predictor of injurious falls in older persons. *J Am*
939 *Geriatr Soc* 45, 735-738.

940 Vereeck, L., Wuyts, F., Truijten, S., Van de Heyning, P., 2008. Clinical assessment of
941 balance: normative data, and gender and age effects. *Int J Audiol* 47, 67-75.

- 942 Vickers, A.J., 2005. Parametric versus non-parametric statistics in the analysis of randomized
943 trials with non-normally distributed data. *BMC Med Res Methodol* 5.
- 944 Ware, J.H., 2006. The limitations of risk factors as prognostic tools. *N Engl J Med* 355, 2615-
945 2617.
- 946 Welmer, A.K., Rizzuto, D., Laukka, E.J., Johnell, K., Fratiglioni, L., 2017. Cognitive and
947 physical function in relation to the risk of injurious falls in older adults: a population-
948 based study. *J Gerontol A Biol Sci Med Sci* 72, 669-675.
- 949 WHO, 2007. WHO Global Report on Falls Prevention in Older Age.
- 950 WHO, 2021. Health Topics Fact Sheet: Falls.
- 951 Wolinsky, F.D., Miller, D.K., Andresen, E.M., Malmstrom, T.K., Miller, J.P., 2005.
952 Reproducibility of physical performance and physiologic assessments. *J Aging Health* 17,
953 111-124.
- 954 Wulf, G., Lewthwaite, R., 2016. Optimizing performance through intrinsic motivation and
955 attention for learning: the optimal theory of motor learning. *Psychon. Bull. Rev.* 23, 1382-
956 1414.
- 957 Wulf, G., McNevin, N.H., Shea, C.H., 2001. The automaticity of complex motor skill
958 learning as a function of attentional focus. *Q. J. Exp. Psychol* 54A, 1143-1154.
- 959 Yamada, M., Ichihashi, N., 2010. Predicting the probability of falls in community-dwelling
960 elderly individuals using the trail-walking test. *Environmental health and preventive
961 medicine* 15, 386-391.
- 962 Yamada, M., Uemura, K., Mori, S., Nagai, K., Uehara, T., Arai, H., Aoyama, T., 2012. Faster
963 decline of physical performance in older adults with higher levels of baseline locomotive
964 function. *Geriatrics & gerontology international* 12, 238-246.
- 965 Yamada, T., Yamato, Y., Hasegawa, T., Yoshida, G., Yasuda, T., Banno, T., Arima, H., Oe,
966 S., Ushirozako, H., Ide, K., Watanabe, Y., Matsuyama, Y., 2020. Influence of the Sagittal
967 Vertical Axis on the Risk of Falls in Community-Dwelling Elderly People: A
968 Retrospective Longitudinal Study. *Spine Surg Relat Res* 4, 237-241.
- 969

Figure 1. PRISMA flow chart outlining identification of eligible studies



B.

Cross-sectional analyses

Andresen et al. (2006): >3s & <30s
≤3s or unable

Blain et al. (2021): <6s, women

men

El Sobkey (2011): cut-point not reported

Eto & Miyauchi (2018): <55.4s

Lim et al. (2016): men <70 years, Q2

Q3

Q4

men ≥70 years, Q2

Q3

Q4

women <70 years, Q2

Q3

Q4

women ≥70 years, Q2

Q3

Q4

Rossat et al. (2010): <5s

Longitudinal analyses

Andresen et al. (2006): >3s & <30s
<3s or unable

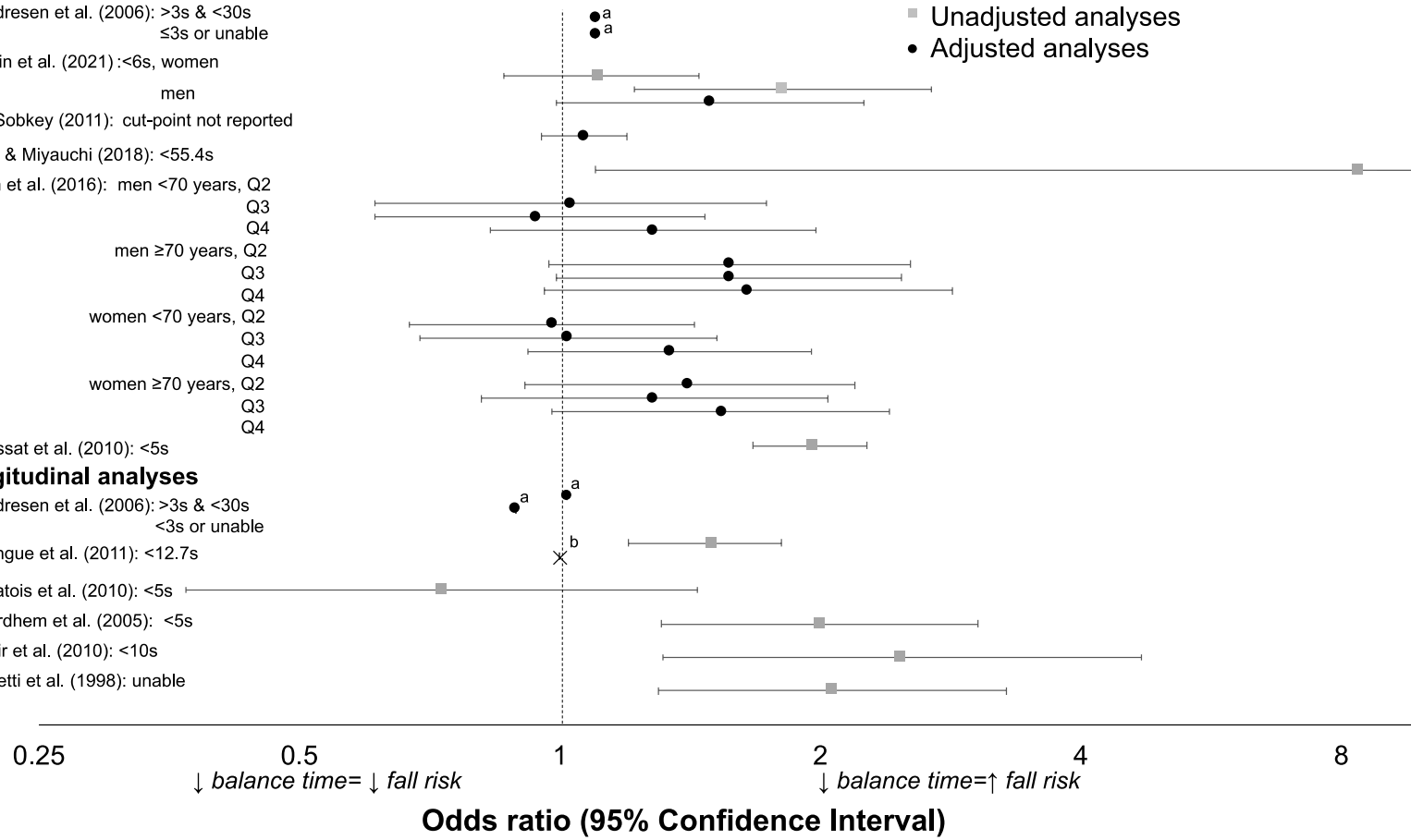
Bongue et al. (2011): <12.7s

Buatois et al. (2010): <5s

Gerdhem et al. (2005): <5s

Muir et al. (2010): <10s

Tinetti et al. (1998): unable



C.

Cross-sectional analyses

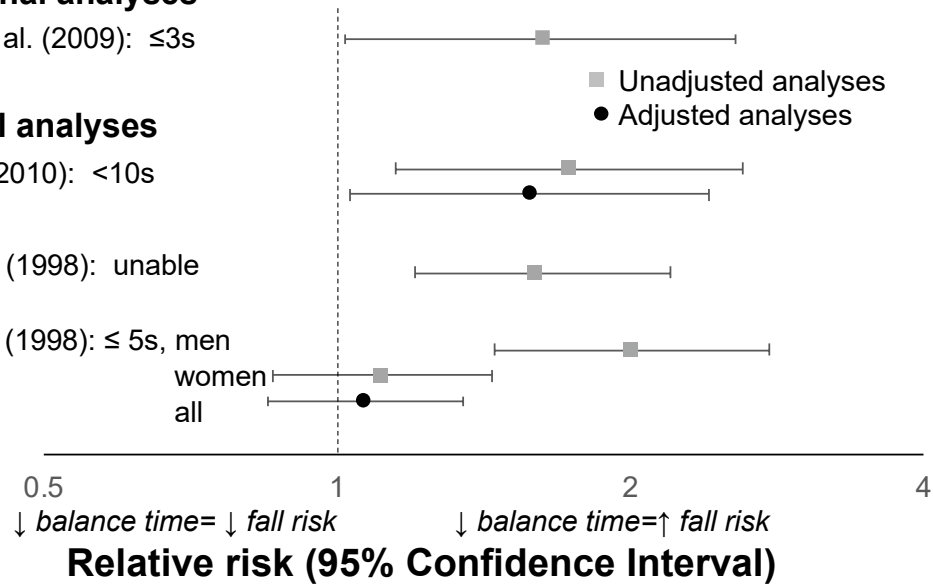
Shimada et al. (2009): ≤3s

Longitudinal analyses

Muir et al. (2010): <10s

Tinetti et al. (1998): unable

Vellas et al. (1998): ≤ 5s, men
women
all



^a Andresen: no 95% CI provided; estimates not significant.

^b Bongue and Gerdhem: adjusted model not reported and not significant;

Reference categories: Andresen 30s; Blain 6-10s; Eto 55.4-120s; Lim highest quartile in age and sex-specific groups (Q1); Rossat 5s; Bongue, 12.7-60s; Buatois 5s; Gerdhem 5-30s; Muir 10s; Tinetti able to stand on one leg; Shimada 3-120s; Vellas 5s;

Figure 3. Risk of any fall (1+): A. Odds ratio per 1s increase in balance time; B. Odds ratio per low balance cut-point; C. Relative risk per low balance cut-point (see study details in Appendix F)

Cross-sectional analyses

Jalali et al. (2015): <12.7s

Rossat et al. (2010): <5s

Swanenburg et al. (2013): <30s

Thomas & Lane (2005): <1.02s

Longitudinal analyses

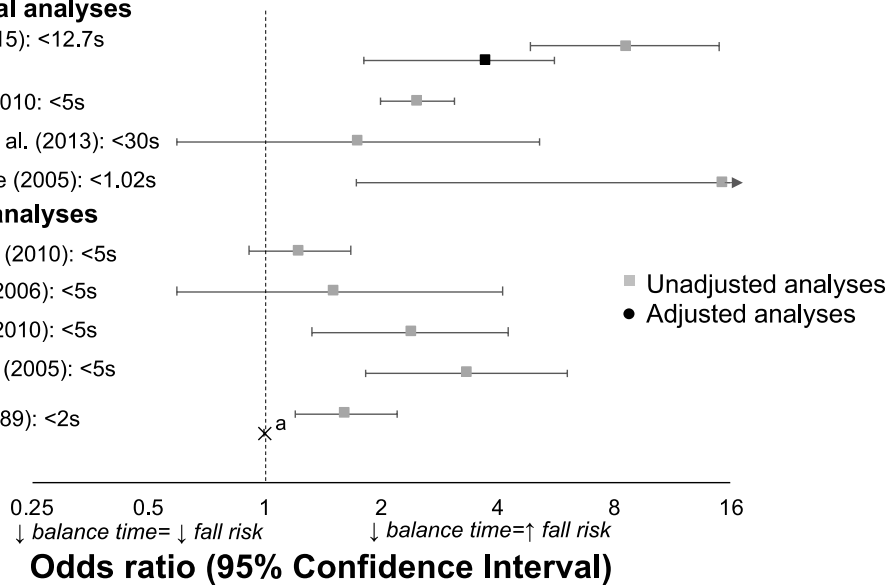
Beauchet et al. (2010): <5s

Buatois et al. (2006): <5s

Buatois et al. (2010): <5s

Gerdhem et al. (2005): <5s

Nevitt et al. (1989): <2s



^a adjusted model not reported and not significant

Figure 4. Odds ratios of recurrent falls (2+ falls) in those with low one-legged balance times compared to single or non-fallers (0-1 falls)

Table 1. Characteristics of included papers (n=55; listed in alphabetic order of first author surnames)

First author, year Study country (and study name where applicable)	Analytical sample size (% women) Age (mean \pm SD, min-max) <i>nr = not recorded</i>	One-legged balance: assessed time (continuous range or categorical cut-points) analysed time (if different) <i>nr = not recorded</i>	Eyes open or closed	Fall temporality: Retrospective or Prospective (recall or follow-up period)	Fall ascertainment	Fall outcomes analysed	Temporality of analyses (cross-sectional or longitudinal) a	Quality score (0-7)
Andresen, 2006 USA African American Health cohort study	998 (58.2%) 56.8 \pm 4.4, <i>nr</i>	Continuous (0-30s) Analysed categorical (unable or \leq 3s; 3-29s; 30s)	Not stated	Retrospective (2 years) Prospective (2 years)	Self-reported in interview Received annual phone calls	0 falls; 1+ falls 0 or non-injurious falls; 1+ injurious falls	Cross-sectional Cross-sectional Longitudinal	5
Ansai, 2016 Brazil	67 (67.2%) <i>nr</i> \pm <i>nr</i> , 80+	Continuous (0-30s)	Open	Retrospective (3 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	3
Arai, 2020 Japan	399 (52.4%) 71.7 \pm 4.2, 65-79	Continuous (0-120s)	Open	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Longitudinal	5
Beauchet, 2010 France	1759 (51.0%) 70.7 \pm 4.6, 65-95	Binary (<5; 5s) Moved arms (yes/no)	Not stated	Prospective (12 months)	Received monthly phone calls	0 falls; 1 fall; 2+ falls	Longitudinal	4
Bergland, 2004 Norway	307 (100%) 80.8 \pm <i>nr</i> , 75-93	Continuous (0- <i>nr</i>) Analysed binary (median cut-off; not stated)	Open	Prospective (12 months)	Submitted falls diary every 3 months	0 or non-injurious falls; 1+ injurious falls	Longitudinal	7
Blain, 2021	1471 (67.0%)	Continuous	Not stated	Retrospective	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	4

France	72.4 ± 5.1, 65- <i>nr</i>	(0-10s) Analysed binary (<6.5; ≥ 6.5s)		(12 months)				
Bongue , 2011 France	1759 (51%) 70.7 ± 4.6, 65-95	Continuous (0-60s) Analysed binary (Dominant leg: <12.7; ≥12.7s Non-dominant leg: <7.6; ≥7.6s)	Open	Prospective (12 months)	Received monthly phone calls	0 falls; 1+ falls	Longitudinal	7
Briggs , 1989 USA	71 (100%) 72.3 ± 7.0, 60-86	Continuous (0-45s)	Open + Closed	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	3
Buatois , 2006 France	189 (43.7%) 70.0 ± 4.0, 65+	Binary (<5; 5s)	Open	Prospective (16 months)	Responded to questionnaire every 4 months	0 falls; 1 fall; 2+ falls	Longitudinal	4
Buatois , 2010 France	1618 (49.3%) 70.3 ± 4.5, 65+	Binary (<5; 5s)	Not stated	Retrospective (mean 25±5 months)	Self-reported questionnaire	0-1 falls; 2+ falls	Longitudinal	4
Cho , 1998 Country not stated	16 (75%) 74.5 ± <i>nr</i> , 65-87	Continuous (0-30s)	Open + Closed	Retrospective (2 years)	Clinician referral of recurrent fallers	0-1 falls; 2+ falls	Cross-sectional	1
Choy , 2007 Australia	456 (100%) <i>nr</i> ± <i>nr</i> , 20-80	Binary (<10; 10s) Analysed categorical (stable, unsteady, unstable)	Open + Closed	Retrospective (12 months)	Self-reported questionnaire	Continuous # of falls	Cross-sectional	1
Choy , 2008 Australia	254 (100%) <i>nr</i> ± <i>nr</i> , 40-80	Binary (<10; 10s) Analysed categorical (stable=3 successful trials; unsteady =1-2 successful trials;	Open	Retrospective (12 months)	Self-reported questionnaire	Continuous # of falls	Cross-sectional	1

		unstable=0 successful trials. Where 10s = success)						
Crenshaw, 2020 USA	120 (100%) 77.1 ± 7.5, 65- <i>nr</i>	Continuous (0-30s)	Not stated	Prospective (12 months)	Complete biweekly falls questionnaires; received reminder letters and phone calls if questionnaires were missing for a month	0 falls; 1+ falls	Longitudinal	5
Depasquale, 2009 USA	58 (67.2%) 80.8 ± 6.7, 65-94	Continuous (0-30s)	Open	Retrospective (2 years)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	2
de Rekeneire, 2003 USA Health, Aging & Body Composition Study	3050 (51.5%) <i>nr</i> ± <i>nr</i> , 70-79	Continuous (0-30s) Analysed categorical (0, 1, 2)	Not stated	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	1
Delbaere, 2006 Australia Sydney Memory and Ageing Study	494 (54%) 77.9 ± 4.1, 70-90	Continuous (0-10s)	Not stated	Prospective (12 months)	Submitted monthly falls diaries	0-1 non-injurious falls; 1 injurious or 2+ falls	Longitudinal	5
Ek, 2019 Sweden SNAC-K	2808 (62.3%) 73 ± 10.3, 60+	Continuous (0-60s) Analysed binary (<5; ≥5s)	Open	Prospective (5 years)	ICD-10 codes via linked health records	0 or non- injurious falls; 1+ injurious falls	Longitudinal	7
Ek, 2019 Sweden SNAC-K	3112 (63.7%) 73.9 ± 10.6, 60+	Continuous (0-60s) Analysed binary (<5; ≥5s)	Open	Prospective (4, 10 years)	ICD-10 codes via linked health records	0 or non- injurious falls; 1+ injurious falls	Longitudinal	7
El Sobkey, 2011 Kingdom of Saudi Arabia	48 (60.4%) 66.5 ± 6.3, 60-85	Continuous (0-45s)	Open + Closed	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls Continuous # of falls	Cross-sectional Cross-sectional	2
Eto, 2018 Japan	159 (64.8%) 74.3 ± 6.3, 65+	Continuous (0-120s)	Open	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	3

Gerdhem, 2005 Sweden	984 (100%) 75 ± 0, 75-75	Continuous (0-30s) Sum of 4 conditions analysed (0-120s)	Open + Closed	Retrospective (1.01±0.05 years)	Self-reported questionnaire	0 falls; 1+ falls 1 fall; 2+ falls	Longitudinal Longitudinal	6
Hasegawa, 2019 Japan Frail Elderly in the Tamba Sasayama- Area study	672 (66.8%) 72.8 ± 5.9, 65+	Continuous (0- <i>nr</i>)	Open	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	4
Hashidate, 2011 Japan	30 (50%) <i>nr</i> ± <i>nr</i> , 65+	Continuous (0- <i>nr</i>)	Open	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	1
Heitmann, 1989 USA	110 (100%) 73.6 ± 7.2, 60-89	Continuous (0-30s)	Open + Closed	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	2
Ikegami, 2019 Japan Obuse study cohort	412 (50.7%) <i>nr</i> ± <i>nr</i> , 50-89	Continuous (0-60s) Analysed per 1SD	Not stated	Retrospective (12 months)	Self-reported in interview	Continuous # of falls	Cross-sectional	4
Jalali, 2015 Iran	448 (46.7%) 73.8 ± 6.3, 65+	Continuous (0- <i>nr</i>) Analysed binary (≤12.7; >12.7s)	Open	Retrospective (12 months)	Self-reported in interview	0-1 falls; 2+ falls	Cross-sectional	4
Kwan, 2011 Taiwan	280 (42.9%) 74.9 ± 6.4, 65-91	Continuous (0-30s)	Open	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	3
Lim, 2016 South Korea Chungju Metabolic Disease Cohort study	5368 (55.8%) 67.7 ± 4.9, 40+	Continuous (0-30s) Analysed categorical (gender & age- specific quartiles)	Not stated	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	3
Lin, 2004 Taiwan	1200 (41%) 73.4 ± <i>nr</i> , 65+	Continuous (0- <i>nr</i>)	Open	Retrospective (12 months) Prospective	Self-reported in interview	0 falls; 1+ falls 0 falls; 1+ falls	Cross-sectional Longitudinal	6

				(12 months)	Reported each fall by postcard & received phone call every 3 months			
Macrae , 1992 USA	94 (69.1%) 73.2 ± 0.8, 60-89	Continuous (0-30s)	Open	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	3
Mahoney , 2019 USA Central Control of Mobility in Aging study	289 (53%) 76.7 ± 6.4, 65-93	Continuous (0-30s)	Not stated	Prospective (24±17 months)	Received phone call every 2-3 months	0 falls; 1+ falls	Longitudinal	6
Moreira , 2005 Brazil Network for Studies on Frailty in the Brazilian Elderly	773 (64%) 71.9 ± 5.9, <i>nr</i>	Continuous (0-60s)	Not stated	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	4
Muir , 2010 Canada Project to Prevent Falls in Veterans	182 (30%) 79.9 ± 4.7, 60+	Binary (<10; 10s)	Open	Prospective (12 months)	Submitted monthly falls diary & received phone call every fall	0 falls; 1+ falls 0 or non-injurious falls; 1+ injurious falls	Longitudinal	6
Mulasso , 2017 Italy	192 (62%) 73 ± 6.2, 65+	Continuous (0-60s)	Not stated	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Longitudinal	6
Nevitt , 1989 USA	325 (81.8%) <i>nr</i> ± <i>nr</i> , 60+	Continuous (0- <i>nr</i>) Analysed binary (<2; ≥2s)	Not stated	Prospective (12 months)	Submitted weekly falls postcards and were contacted if missing postcard	0-1 falls; 2+ falls	Longitudinal	6
Niam , 1999 Singapore	68 (67.2%) 71.7 ± 8.1, 60-89	Continuous (0-60s)	Open	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	1
Park , 2020 South Korea	39 (74.4%) 79 ± 5.3, 65- <i>nr</i>	Continuous (0-45s)	Open	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional	4

Porto, 2020 Brazil	101 (77.2%) 67.6 ± 5.0, 60- <i>nr</i>	Continuous (0-30s)	Not stated	Prospective (12 months)	Received monthly phone calls	0 falls; 1+ falls 1 fall; 2+ falls	Longitudinal Longitudinal	7
Rossat, 2011 France	7643 (50.5%) 70.9 ± 4.6, 65+	Binary (<5; 5s)	Not stated	Retrospective (12 months)	Self or proxy-reported questionnaire	0 falls; 1 fall; 2 falls; 3+ falls Continuous #of falls	Cross-sectional	4
Sampaio, 2013 Japan & Brazil	114 (80%) 71.8 ± 4.3, 65+	Continuous (0-30s)	Not stated	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	3
Shimada, 2009 Japan	455 (67.1%) 81.4 ± 7.8, 65+	Continuous (0-120s) Analysed continuous and binary (≤3; >3s)	Not stated	Retrospective (12 months)	Self or proxy-reported questionnaire	0 falls; 1+ falls	Cross-sectional	4
Shimada, 2011 Japan	213 (61%) 80 ± 7.1, 65+	Continuous (0-120s)	Not stated	Retrospective (3 months)	Self or proxy-reported questionnaire	0 falls; 1+ falls	Cross-sectional	2
Shinohara, 2020 Japan	109 (84.4%) 76.9 ± 6.5, 65- <i>nr</i>	Continuous (0-30s)	Not stated	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	2
Shin, 2012 South Korea	356 (66.6%) 71.6 ± 4.9, 65+	Continuous (0-20s)	Open + Closed	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Cross-sectional	4
Swanenburg, 2013 Switzerland	146 (69.9%) 55 ± 22, 20-94	Continuous (0- <i>nr</i>) Analysed binary (<30; ≥30s)	Not stated	Retrospective (12 months)	Self-reported in interview	0-1 falls; 2+ falls	Cross-sectional	1
Thomas, 2005 United Kingdom	30 (53.9%) 80.4 ± 6.7, 65+	Continuous (0- <i>nr</i>) Analysed binary (≤1.02; >1.02)	Not stated	Retrospective (12 months)	Self-reported in interview; verified with medical notes and records	0-1 falls; 2+ falls	Cross-sectional	4
Tinetti, 1988 USA	336 (55%) 78.3 ± 5.1, 75+	Binary (unable to stand unsupported on one leg; able)	Open	Prospective (12 months)	Submitted bimonthly falls diaries & received bimonthly phone calls	0 falls; 1+ falls	Longitudinal	5

Yale Health and Aging Project								
Toulotte , 2006 France	40 (100%) 68.8 ± 5.6, 60+	Analysed # of times foot touched ground in 30s	Open + Closed	Retrospective (2 years)	Self-reported in two independent blinded interviews	0 falls; 1+ falls	Cross-sectional	4
Vellas , 1997 USA Albuquerque Falls Study	316 (59%) 72.7 ± 6.1, 60+	Binary (<5; 5s)	Open	Prospective (3 years)	Submitted bimonthly falls postcards & initiated phone call every fall	0 falls; 1+ falls 0 or non-injurious falls; 1+ injurious falls	Longitudinal	7
Vellas , 1998 USA Albuquerque Falls Study	405 (59%) 74 ± 6.7, 60+	Binary (<5; 5s)	Not stated	Prospective (2 years)	Submitted bimonthly falls postcards & initiated phone call every fall	0 falls; 1+ falls 0 or non-injurious falls; 1+ injurious falls	Longitudinal Longitudinal	6
Welmer , 2017 Sweden SNAC-K	2495 (61.9%) 72 ± 9.8, 60+	Continuous (0-60s)	Open	Prospective (3, 5, 10 years)	ICD-10 codes via linked health records	0 or non-injurious falls; 1+ injurious falls	Longitudinal	7
Yamada , 2010 Japan	171 (78.4%) 80.5 ± 5.6, 65+	Continuous (0- <i>nr</i>)	Open	Prospective (12 months)	Submitted monthly falls postcards	0 falls; 1+ falls	Longitudinal	5
Yamada , 2012 Japan	252 (76.6%) 78.3 ± 6.8, 65+	Continuous (0-60s)	Open	Retrospective (12 months)	Self-reported in interview	0 falls; 1+ falls	Cross-sectional Longitudinal	5
Yamada , 2020 Japan	471 (79.6%) 72.3 ± 7.3, 50- <i>nr</i>	Continuous (0- <i>nr</i>)	Open	Retrospective (12 months)	Self-reported questionnaire	0 falls; 1+ falls	Longitudinal	5

ICD International Classification of Diseases; SNAC-K Swedish National Study on Ageing and Care in Kungsholmen; USA United States of America

^a Cross-sectional refers to analysis of balance and falls measures assessed at the same time. Longitudinal refers to analysis, where balance is assessed at baseline and falls are assessed after a given follow-up period.

For further study details, see Supplementary Table 1.

Table 2. Median balance time (seconds) by fallers and non-fallers

Author	Sample size	Balance time in fallers (s) Median (Q1, Q3)	Balance time in non-fallers (s) Median (Q1, Q3)	P-value
Shimada et al. (2011)	213	3 (IQR=4.0)	4 (IQR=6.0)	0.31
Sampaio et al. (2013)	Japan 40	15.2 (6.1, 29.0)	24.1 (9.2, 30.0)	0.56
	Brazil 74	13.9 (3.9-23.3)	12.7 (6.5, 26.2)	0.54
Ansai et al. (2020)	67	2.3 (1.4, 6.7)	3.1 (1.1, 9.4)	0.53
Heitmann et al. (1989)	110	4.62 (<i>nr</i>)	4.24 (<i>nr</i>)	>0.05
Niam & Wee (1999)	68	<i>nr</i>	<i>nr</i>	>0.05
Eto & Miyauchi (2018)	159	<i>nr</i>	<i>nr</i>	0.10
Hashidate et al. (2011)	30	<i>nr</i>	<i>nr</i>	>0.05
Arai et al. (2020) ^a	399	<i>nr</i>	<i>nr</i>	0.12

POOLED MEDIAN DIFFERENCE: 1.0 (-1.2, 8.9)^b

Q1 = 25th percentile; *Q3*: 75th percentile; *nr*=not reported; *IQR*: interquartile range (*Q3* – *Q1*)

^a Longitudinal study; all other studies are cross-sectional

^b A positive difference indicates that non-fallers have longer balance time than fallers, while a negative difference indicates that fallers have longer balance times than non-fallers

Table 3. Prognostic accuracy of balance test in predicting falls

Author	Cut-point	Sensitivity (%) ^a	Specificity (%) ^b	Positive Predictive Value (%) ^c	Negative Predictive Value (%) ^d	AUC (95% CI) ^e
ANY FALL (cross-sectional)						
Depasquale & Toscano (2009)	<6.5	48.3	89.7	82.4%	63.4%	0.766
Eto & Miyauchi (2018)	<55.4	-	-	-	-	0.533
Lin et al. (2004)	-	-	-	-	-	0.640
Rossat et al. (2010)	<5s	20.8 ^f	88.1 ^f	29.8 ^f	82.1 ^f	-
Shimada et al. (2009)	<3	51	61	-	-	-
ANY FALL (longitudinal)						
Beauchet et al. (2010) dominant	<5s	34.5 ^f	73.0 ^f	37.5 ^f	70.3 ^f	-
Bongue et al. (2011) non-dominant	<7.6s	46.0 ^f	65.3 ^f	38.4 ^f	72.0 ^f	0.56 (0.53,0.59)
Bongue et al. (2011) dominant	<12.7s	60.9 ^f	49.1 ^f	36.0 ^f	72.7 ^f	0.55 (0.53,0.58)
Beauchet et al. (2010) ^g Moved arms	Moved arms	50.6 ^f	59.7 ^f	37.2 ^f	72.0 ^f	-
Bongue et al. (2011) ^g Moved arms	Moved arms	50.6 ^f	59.7 ^f	37.2 ^f	72.0 ^f	-
Buatois et al. (2006)	<5s	28.1 ^f	65.2 ^f	25.8 ^f	67.7 ^f	-
Crenshaw et al. (2020)	per 1SD	-	-	-	-	0.56
Gerdhem et al. (2005)	per 1s	-	-	-	-	0.55 (0.51-0.60)
Lin et al. (2004)	per 1s	-	-	-	-	0.527
Muir et al. (2010)	<10s	74.4 ^f	46.2 ^f	50.9 ^f	70.6 ^f	-
Tinetti et al. (1988)	Unable	56.5 ^f	61.4 ^f	40.9 ^f	90.4 ^f	-
RECURRENT FALLS (cross-sectional)						
Jalali et al. (2015) ^h	<12.7	83.5	63	47.6	90.4	-
Swanenburg et al. (2013)	<30	61.1 ^f	52.5 ^f	28.2 ^f	81.6 ^f	-
Rossat et al. (2010)	<5s	26.6 ^f	87.2 ^f	12.1 ^f	94.7 ^f	-
Thomas & Lane (2005)	<1.02	67 (39-86)	89 (67-97)	-	-	-
RECURRENT FALLS (longitudinal)						
Beauchet et al. (2010)	<5	33	71.2	14.3	88.1	-
Beauchet et al. (2010)	Moved arms	55.9	58.2	16.2	90.1	-
Buatois et al. (2006)	<5s	16.7 ^f	90.3 ^f	15.4 ^f	91.1 ^f	-
Buatois et al. (2010)	<5s	42.1 ^f	68.2 ^f	12.9 ^f	91.3 ^f	-
Gerdhem et al. (2005)	<5s	28.8 ^f	89.1 ^f	14.5 ^f	95.1 ^f	-
INJURIOUS FALLS (longitudinal)						
Vellas et al. (1997)	<5	-	36	76	31	-

^a Proportion of fallers who had a positive screening test (e.g. balance time < cut-point) (Parikh et al., 2008)

^b Proportion of non-fallers who had a negative screening test (e.g. balance time ≥ cut-point) (Parikh et al., 2008)

^c Proportion of those with a positive screening test (e.g. balance time < cut-point) who have a fall (Parikh et al., 2008)

^d Proportion of those with a negative screening test (e.g. balance time ≥ cut-point) who do not have a fall (Parikh et al., 2008)

^e Area under the curve

^f Calculated using available data from paper

^g Same sample; values for moved arms identical in both papers

^h Values calculated from sample size; sensitivity, specificity, positive predictive value, and negative predictive value are incorrect in paper