

Additional file 2: PROSPECTIVE STUDIES reporting factors that are longitudinally associated with back pain.

Back pain, sample characteristics and associations between back pain and temporal precursor variables. Prospective Studies

| Reference | Back pain | | | | Characteristics of study sample | Significant positive (+) or negative (-) associations with back pain | | | | | | | | | | |
|--|-----------|-----|-----|---|---------------------------------|--|------------------|------|--------|------|------|-----------------|-------------------|-----------------------|--------|---|
| | MBP | LBP | Mix | ? | | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | Female | Male | Age | Pubertal status | Family history BP | Socioeconomic factors | Height | History of back pain |
| [10] Auvinen, (2010), Finland, 1773 | | X | | | 2/4 | 15-16 | Both | + | | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Female: OR 1.7 (1.4-2.0) (age 16), OR 1.9 (1.6-2.3) (age 18) (calculated) |
| [11] Balague', (2010), Switzerland, 95 | | X | | | 2/4 | 13-14 (14.0) | Male | (NT) | (NT) | (NT) | (NT) | + | (NT) | (NT) | (NT) | Family history: OR 3.6 (1.3-10.2) |
| [4] Feldman, (2001), Canada, 502 | | X | | | 2/4 | 13-14 (13.8) | Both | 0 | 0 | 0 | (NT) | (NT) | (NT) | + | (NT) | High growth spurt: OR 3.1 (1.5-6.0) |
| [16] Franz, (2016), Denmark, 1240 | X | X | X | | 4/4 | 6-12 | Both | + | | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Incidence rate (per 1000): Girls: 0.3 (0.2-0.3), Boys: 0.1 (0.1-0.2) (OR 1.9 (1.4-2.4) (calculated)) |
| [17] Gill, (2014), Australia, 1291 | X | X | X | | 2/4 | (14) | Both | + | | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Females: (X ² = 33.1, p < .001) (OR 2.4 (1.9-3.1) (calculated LBP)) (OR 2.2 (1.6-2.9) (calculated MBP)) |
| [18] Hebert, (2019), Denmark, 1021 | | | X | | 4/4 | (9.4) | Both | (NT) | (NT) | (NT) | + | (NT) | (NT) | + | (NT) | Spinal pain (wks), later pubertal status: Tanner stage 2: IRR 1.5 (1.2-2.0) Tanner stage 3: IRR 2.1 (1.5-3.1) Tanner stage 4/5: IRR 3.3 (2.1-5.0) Spinal pain (episodes), pubertal status: Tanner stage 3: 1.4 (1.0-1.8) Tanner stage 4/5: 2.1 (1.4-3.0) Spinal pain (wks): linear growth: IRR 1.2 (1.2-1.2) Spinal pain (episodes), linear growth: IRR 1.1 (1.1-1.2) |

| Reference | Back pain | | | | | Characteristics of study sample | | Significant positive (+) or negative (-) associations with back pain | | | | | | | | |
|---|-----------|-----|-----|---|--|---------------------------------|------|--|------|------|-----------------|-------------------|-----------------------|--------|----------------------|---|
| | MBP | LBP | Mix | ? | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | Female | Male | Age | Pubertal status | Family history BP | Socioeconomic factors | Height | History of back pain | Significant estimates (95% CI) |
| [21] Hestbaek, (2006), Denmark, 9600 | | X | | | 4/4 | 12-22 (17.3) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | BP in adolescence for BP in adulthood: OR 4.3 (3.5-5.4) |
| [22] Janssens, (2011), USA/ Denmark 4226 | | | | X | 1/4 | 11-15 (11.6) / (13.7) | Both | (NT) | (NT) | (NT) | + | (NT) | (NT) | 0 | (NT) | Later pubertal status: OR 1.6 (1.3-2.0) (USA) OR 1.3 (1.1-1.6) (Dutch) |
| [23] Jones, (2009), England, 178 | | X | | | 2/4 | 11-14 | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) | Shorter than median height (158cm): RR 2.1 (1.2-3.8) |
| [24] Jones, (2003), England, 1046 | | X | | | 2/4 | 11-14 | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | 0 | (NT) | |
| [26] Kroner-Herwig, (2017), Germany, 1522 | | | | X | 1/4 | 7-14 (13.4) | Both | + | | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Female: OR 1.6 (1.2-2.0) |
| [27] Mattila, (2008), Finland, 57408 | | X | | | 2/4 | 14-18 (16.6) | Both | | + | (NT) | - | (NT) | (NT) | (NT) | (NT) | Males: HR 3.2 (2.7-3.7) Later pubertal status: HR 0.6 (0.5-0.8) (males) |
| [28] Mikkonen, (2016), Finland, 1625 | | X | | | 2/4 | 15-16 | Both | + | | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Female: Girls 44%, boys 31% (OR 1.7 (1.4-2.1) (calculated)) |
| [29] Mikkonen, (2013), Finland, 1660 | | X | | | 2/4 | 15-16 | Both | + | | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Female: prevalence percentage girls 61%, boys 49% (OR 1.6 (1.4-2.0) (calculated)) |

| Reference | Back pain | | | | Characteristics of study sample | Significant positive (+) or negative (-) associations with back pain | | | | | | | | | | |
|-------------------------------------|-----------|-----|-----|---|---------------------------------|--|------------------|------|--------|------|------|-----------------|-------------------|-----------------------|--------|---|
| | MBP | LBP | Mix | ? | | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | Female | Male | Age | Pubertal status | Family history BP | Socioeconomic factors | Height | History of back pain |
| [31] Nissinen, (1994), Finland, 859 | | X | | | 2/4 | 10-11 (10.8) | Both | 0 | 0 | (NT) | (NT) | (NT) | (NT) | + | (NT) | Height: OR 1.2 (1.0-1.5) |
| [32] Sano, (2015), Japan, 4597 | | X | | | 2/4 | 9-10 | Both | 0 | 0 | + | (NT) | (NT) | (NT) | (NT) | (NT) | Age: 9 yr 10%, 14 yr 25% (OR 2.9 (2.6-3.3) (calculated) |
| [33] Sjolie, (2004), Norway, 85 | | X | | | 2/4 | 14-16 (14.7) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | History of BP: OR 2.7 (1.1-7.1) (ever) OR 9.1 (3.0-27.2) (>7days) |
| [34] Smith, (2017), Australia, 1088 | | X | | | 3/4 | (14) | Both | + | | (NT) | (NT) | (NT) | + | (NT) | + | Females: OR: 2.0 (1.2- 3.0) (no previous BP) OR 7.7 (4.7, 12.6) (previous BP) Higher socioeconomic index: OR 0.8 (0.7-1.0) History of BP: OR 7.7 (4.7-12.6)(girl) |
| [35] Szita, (2018), Hungary, 952 | X | X | X | | 3/4 | 7-16 (11.0) | Both | 0 | 0 | + | (NT) | + | (NT) | (NT) | (NT) | Older age: OR 1.5 (1.1-2.3) Family history: OR 2.1 (1.4-3.1) |
| [36] Szpalski, (2002), Belgium, 287 | | X | | | 1/4 | 9-12 | Both | (NT) | (NT) | (NT) | (NT) | + | (NT) | (NT) | (NT) | Family history: OR 2.0 (1.1-4.0) |

Pub: Publication, (NT): Not tested, (NR): Included in study but not reported, + significant positive association, - significant negative association, 0: tested but non-significant estimate, OR: odds ratio, PR: prevalence ratio, RR: relative risk

Back pain, sample characteristics and associations between back pain and some bidirectional variables. Prospective Studies

| Reference | Back Pain | | | | Characteristics of study sample | Significant positive (+) or negative (-) associations with back pain | | | | | | | | | | | | |
|--|-----------|-----|-----|---|--|--|------|------|-----------------|-----------------------|---------|------------------------|-------------|------------|------------|-------|-----------------------|--|
| Reference (year of pub), country, pop size | MBP | LBP | Mix | ? | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | BMI | Muscle strength | Flexibility Tightness | Posture | Physical activity/work | Screen time | Poor Sleep | Carry Bags | Smoke | Illness/ Psychosocial | Significant estimates (95% CI) |
| [9] Aartun, (2016), Denmark, 625 | X | X | X | | 3/4 | 11-13 | Both | (NT) | (NT) | (NT) | (NT) | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | |
| [10] Auvinen, (2010), Finland, 1773 | | X | | | 2/4 | 15-16 | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) | (NT) | (NT) | Insufficient Sleep: OR 2.9 (1.7-5.2) (girls) OR 2.4 (1.3-4.5) (boys) |
| [11] Balague', (2010), Switzerland, 95 | | X | | | 2/4 | 13-14 (14.0) | Male | + | (NT) | (NT) | (NT) | + | (NT) | (NT) | (NT) | (NT) | (NT) | Higher BMI: OR 1.3 (1.0-1.5) Playing sport: OR 9.5 (1.9-48.2) |
| [12] Deere, (2012), England, 3378 | X | X | | | 2/4 | 17 (17.8) | Both | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | |
| [13] Feldman, (2002), Canada, 502 | | X | | | 2/4 | 13-14 (13.8) | Both | (NT) | (NT) | (NT) | (NT) | + | (NT) | (NT) | (NT) | (NT) | (NT) | White collar work: OR 4.9 (1.7-14.2) |
| [4] Feldman, (2001), Canada, 502 | | X | | | 2/4 | 13-14 (13.8) | Both | (NT) | (NT) | + | (NT) | 0 | (NT) | (NT) | (NT) | + | (NT) | Tight hamstrings: OR 1.1 (1.0-1.1) Smoking: OR 2.2 (1.4-3.5) |
| [14] Feldman, (1999), Canada, 502 | | X | | | 2/4 | 13-14 (13.8) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) | Smoking: OR 2.4 (1.3-6.0) |
| [15] Franz, (2017), Denmark, 1205 | X | X | X | | 4/4 | 6-12 | Both | (NT) | (NT) | (NT) | (NT) | + | (NT) | (NT) | (NT) | (NT) | (NT) | Vigorous intensity physical activity: OR 1.2 (1.0-1.4) (diagnostic spinal pain) OR 1.3 (1.0-1.5) (traumatic) |

| Reference | Back Pain | | | | Characteristics of study sample | Significant positive (+) or negative (-) associations with back pain | | | | | | | | | | | | |
|---|-----------|-----|-----|---|---------------------------------|--|------------------|------|------|-----------------|-----------------------|---------|------------------------|-------------|------------|------------|-----------|---|
| | MBP | LBP | Mix | ? | | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | BMI | Muscle strength | Flexibility Tightness | Posture | Physical activity/work | Screen time | Poor Sleep | Carry Bags | Smoke | Illness/ Psychosocial |
| [16] Franz, (2016), Denmark, 1240 | X | X | X | | 4/4 | 6-12 | Both | (NT) | (NT) | (NT) | (NT) | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | |
| [17] Gill, (2014), Australia, 1291 | X | X | X | | 2/4 | (14) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) 0 | Smoking: OR 3.1 (1.1-9.2) (MB) OR: 1.8 (1.2-2.8) (BP) |
| [19] Hestbaek, (2006), Denmark, 9600 | | X | | | 4/4 | 12-22 (17.3) | Both | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) | Smoking: OR 1.7 (1.4-2.1) |
| [20] Hestbaek, (2006), Denmark, 9600 | | X | | | 4/4 | 12-22 (17.3) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | Asthma: OR 1.4 (1.1-1.7) (female) Headache: OR 1.6 (1.1-2.1) (female) OR 2.4 (1.2-4.7) (male) |
| [23] Jones, (2009), England, 178 | | X | | | 2/4 | 11-14 | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | 0 + | High level of peer problems: RR 2.3 (1.3-4.2) |
| [24] Jones, (2003), England, 1046 | | X | | | 2/4 | 11-14 | Both | 0 | (NT) | (NT) | (NT) | + | 0 | (NT) | 0 | (NT) | + | High level of sports activity (>18hr/wk): RR 1.6 (1.1-2.3) Part-time work: RR 1.5 (1.1-2.1) Abdominal pain: RR 1.8 (1.1-3.0) High level of psychological factors: RR 1.6 (1.1-2.3) |
| [25] Kanchanomai, (2015), Thailand, 524 | | X | | | 2/4 | 18-25 (19.4) | Both | (NT) | (NT) | + | + | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Tight quad muscle: OR 1.7 (1.1-2.8) No LB support: OR 1.7 (1.2-2.6) OR 2.9 (1.1-3.5) (persistent LBP) |

| Reference | Back Pain | | | | | Characteristics of study sample | | Significant positive (+) or negative (-) associations with back pain | | | | | | | | | | |
|---|-----------|-----|-----|---|--|---------------------------------|------|--|-----------------|-----------------------|---------|------------------------|-------------|------------|------------|-------|-----------------------|--|
| | MBP | LBP | Mix | ? | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | BMI | Muscle strength | Flexibility Tightness | Posture | Physical activity/work | Screen time | Poor Sleep | Carry Bags | Smoke | Illness/ Psychosocial | Significant estimates (95% CI) |
| [26] Kroner-Herwig, (2017), Germany, 1522 | | | | X | 1/4 | 7-14 (13.4) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | Headache: OR 2.4 (1.8-3.1) |
| [27] Mattila, (2008), Finland, 57408 | | X | | | 2/4 | 14-18 (16.6) | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) | Daily smoking: HR 1.6 (1.4-1.9) |
| [28] Mikkonen, (2016), Finland, 1625 | | X | | | 2/4 | 15-16 | Both | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | Externalising behaviour: RR: 1.5 (1.3-1.7) (boys) RR: 1.4 (1.3-1.5) (girls) RR: 3.6 (1.5-8.5) (girls 18) |
| [29] Mikkonen, (2013), Finland, 1660 | | X | | | 2/4 | 15-16 | Both | + | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | BMI: RR 1.1 (1.0-1.2) (girls) RR: 1.1 (1.0-1.3) (boys) |
| [30] Mikkonen, (2008), Finland, 1987 | | X | | | 2/4 | 15-16 | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | (NT) | Smoking: OR 2.5 (1.4-4.5) (females) |
| [31] Nissinen, (1994), Finland, 859 | | X | | | 2/4 | 10-11 (10.8) | Both | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | |
| [32] Sano, (2015), Japan, 4597 | | X | | | 2/4 | 9-10 | Both | + | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | High BMI range: OR 2.9 (1.7-5.1) (9 yr) OR 2.2 (1.4-3.5) (10 yr) OR 1.6 (1.2-2.1) (13 yr) |
| [33] Sjolie, (2004), Norway, 85 | | X | | | 2/4 | 14-16 (14.7) | Both | (NT) | (NT) | (NT) | + | + | 0 | (NT) | (NT) | (NT) | (NT) | Provoked by sitting: OR 3.8 (1.3-11.3) Provoked by manual work: OR 9.2 (2.9-28.8) |

| Reference | Back Pain | | | | Characteristics of study sample | Significant positive (+) or negative (-) associations with back pain | | | | | | | | | | | | | |
|-------------------------------------|-----------|-----|-----|---|---------------------------------|--|------------------|------|------|-----------------|-----------------------|---------|------------------------|-------------|------------|------------|-------|-----------------------|--|
| | MBP | LBP | Mix | ? | | Clear definition of BP (x/4) (Additional file 4) | Age range (mean) | Sex | BMI | Muscle strength | Flexibility Tightness | Posture | Physical activity/work | Screen time | Poor Sleep | Carry Bags | Smoke | Illness/ Psychosocial | Significant estimates (95% CI) |
| [34] Smith, (2017), Australia, 1088 | | X | | | 3/4 | (14) | Both | (NT) | + | (NT) | + | + | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) + | Poor back muscle endurance: OR 1.9 (1.2-3.0) Non-neutral standing posture: OR 2.2 (1.3-3.6) Increased physical activity: OR 1.9 (1.2-2.8) High levels of aggressive behaviour: OR 1.4 (1.2-1.6) High levels of somatic complaints: OR 1.3 (1.1-1.5) |
| [35] Szita, (2018), Hungary, 952 | X | X | X | | 3/4 | 7-16 (11.0) | Both | (NT) | (NT) | (NT) | + | 0 | + | + | 0 | (NT) | (NT) | | Increased TV time: OR 2 (1.4-2.9) Uncomfortable school desk: OR 6.0 (3.7-9.7) Frequent sleeping problems: 2.2 (1.7-3.8) |
| [36] Szpalski, (2002), Belgium, 287 | | X | | | 1/4 | 9-12 | Both | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | + | + | (NT) | (NT) | | Quality of sleep: OR 1.2 (1.1-1.4) Heavy school satchel: OR 2.2 (1.0-4.8) |
| [37] Tobias, (2013), UK, 2901 | X | X | | | 3/4 | 13 (13.8) | Both | (NT) | (NT) | 0 | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | (NT) | |

Pub: Publication, (NT): Not tested, (NR): Included in study but not reported, + significant positive association, - significant negative association, 0: tested but non-significant estimate, OR: odds ratio, PR: prevalence ratio, RR: relative risk