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| **Appendix Table 4. Associations between maturity, growth, and musculoskeletal conditions** | | | | | | |
| **Prospective associations between biological maturity and back, neck or extremity pain, or any report of MSK pain** | | | | | | |
| **Pain type** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Back pain | Status | Dunn 2011 - LCGA | ↑PDS score, ↑%back pain (3-years) | ↓%back pain PDS=2.02 vs. ↑%back pain PDS=2.07-2.42 |  | Positive |
| Janssens 2011a - Ord Log Reg | ↑PDS score, ↑back pain (2-3-years) | \*OR 1.34 [1.13-1.57] | Gender | Positive |
| Boys: ↑PDS score, ↑back pain (2-3-years) | OR 1.37 [1.05–1.79] |  | Positive |
| Girls: ↑PDS score, ↑back pain (2-3-years) | OR 1.31 [1.07–1.61] |  | Positive |
| Janssens 2011b - Ord Log Reg | ↑PDS score, ↑back pain (2-3-years) | \*OR 1.61 [1.30-1.99] | Gender | Positive |
| Boys: ↑PDS score, ↑back pain (2-3-years) | OR 1.90 [1.28–2.82] |  | Positive |
| Girls: ↑PDS score, ↑back pain (2-3-years) | OR 1.50 [1.16–1.93] |  | Positive |
| Timing | Mattila 2008 - Cox Reg | Boys: Late pubertal timing (first ejaculation), ↓LBP hospitalisation (mean 11-years) | Late puberty: HR 0.6 [0.5-0.8] |  | Positive |
| Girls: No association. Puberty timing (first menstruation), LBP hospitalisation (mean 11-years) | Late puberty: HR 0.9 [0.6-1.6] |  | No association |
| **Prospective associations between growth and back, neck or extremity pain, or any report of MSK pain** | | | | | | |
| **Pain type** | **Growth** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Back Pain | Spurt | Feldman 2001 – GEE & Descriptive | High growth spurt (>5cm in a 6-month period), ↑LBP (12-months) | \*OR 3.09 [1.53, 6.01] | Age, gender, smoking, initial height, and mental health score | Positive |
| Janssens 2011a – Log Reg | No association. Growth spurt (single item - PDS), back pain (2-3-years) | \*OR 1.13 [0.98-1.31] | unclear: gender, age, functional somatic symptoms | No association |
| Janssens 2011b – Log Reg | No association. Growth spurt (single item - PDS), back pain (2-3-years) | \*OR 1.04 [0.89-1.21] | unclear: gender, age, functional somatic symptoms | No association |
| Picavet 2016 - Log Reg | No association. Upper 20% weight gain, Back complaints (3-years) | \*OR 1.25 [0.82-1.91] | Sex, age | No association |
| No association. Upper 20% height gain, Back complaints (3-years) | \*OR 1.08 [0.67-1.73] | Sex, age | No association |
| Rate | Feldman 2001 – GEE & Descriptive | ↑ absolute growth (cm in 6-months), ↑LBP (12-months) | LBP=1.7cm vs. no-LBP =1.0cm |  | Positive |
| No Association. Absolute growth (cm in 12-months), LBP (18-months) | LBP=3.4cm vs. no-LBP=2.8cm |  | No association |
| Nissinen 1994 – Log Reg | Boys: No association. Standing height growth (cm/year), LBP (2-years) | OR 1.01 [0.98-1.04] |  | No association |
| Girls: No association. Standing height growth (cm/year), LBP (2-years) | OR 0.99 [0.97-1.02] |  | No association |
| Boys: No association. Sitting height growth (cm/year), LBP (2-years) | OR 1.01 [0.98-1.03] |  | No association |
| Girls: No association. Sitting height growth (cm/year), LBP (2-years) | OR 1.01 [0.98-1.03] |  | No association |
| No association. Body mass growth (kg/m2/year), LBP (2-years) | \*OR 1.22 [0.93-1.57] | Sitting height, BMI, growth BMI, Kyphosis, Increase kyphosis, Hump size | No association |
| Boys: No association. Body mass growth (kg/m2/year), LBP (2-years) | OR 1.12 [0.88-1.43] |  | No association |
| Girls: No association. Body mass growth (kg/m2/year), LBP (2-years) | OR 1.37 [0.87-1.96] |  | No association |
| Poussa 2005 – Log Reg | ↑Growth of body height (11 to 14 years-of-age), ↑LBP (at 22 years of age) | \*OR 1.32 [1.06–1.66] | unclear | Positive |
| Men: ↑Growth of body height (11 to 14 years-of-age), ↑LBP (at 22 years of age) | \*OR 1.36 [1.01–1.85] | unclear | Positive |
| Women: No association. Growth of body height (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 1.25 [0.92–1.69] | unclear | No association |
| No association. Sitting height growth (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 1.11 [0.89–1.38] | unclear | No association |
| Men: No association. Sitting height growth (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 1.21 [0.89–1.65] | unclear | No association |
| Women: No association. Sitting height growth (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 0.99 [0.73–1.36] | unclear | No association |
| No association. BMI change (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 1.07 [0.83–1.36] | unclear | No association |
| Men: No association. BMI change (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 0.99 [0.72–1.36] | unclear | No association |
| Women: No association. BMI change (11 to 14 years-of-age), LBP (at 22 years of age) | \*OR 1.15 [0.80–1.67] | unclear | No association |
| Hulsegge 2011 - Imp Reg | No association. Height growth (cm/year), Back complaint (3-years) | OR 0.97 [0.77-1.22] |  | No association |
| No association. Weight growth (kg/year), Back complaint (3-years) | OR 1.05 [0.86-1.29] |  | No association |
| Any MSK condition | Spurt | Picavet 2016 - Log Reg | No association. Upper 20% weight gain, Any musculoskeletal complaint (3-years) | \*OR 1.05 [0.77-1.42] | Sex, age | No association |
| No association. Upper 20% height gain, Any musculoskeletal complaint (3-years) | \*OR 1.05 [1.00-1.10] | Sex, age | No association |
| Rate | Hulsegge 2011 - Imp Reg | No association. Height growth (cm/year), Any musculoskeletal complaint (3-years) | OR 1.04 [0.94-1.15] |  | No association |
| No association. Weight growth (kg/year), Any musculoskeletal complaint (3-years) | OR 1.10 [1.01-1.21] |  | No association |
| Neck-limb pain | Spurt | Ehrmann Feldman 2002 - GEE | No association. High growth spurt (>5cm in a 6-month period), Neck and upper limb pain (12-months) | \*OR 1.80 [0.93, 3.48] | age, gender, height, body mass index, smoking, activity participation and mental health index | No association |
| Extremity pain | Spurt | Shrier 2001 - GEE | No association. High growth spurt (>5cm in 6months), Lower limb pain (12-months) | \*OR 0.93 [0.50-1.71] | age, sex, smoking, activity participation, smoking, and mental health status | No association |
| No association. High growth spurt (>5cm in 6months), Hip pain (12-months) | \*OR 0.50 [0.13-2.18] | age, sex, smoking, activity participation, smoking, and mental health status | No association |
| No association. High growth spurt (>5cm in 6months), Knee pain (12-months) | \*OR 1.17 [0.53-2.59] | age, sex, smoking, activity participation, smoking, and mental health status | No association |
| No association. High growth spurt (>5cm in 6months), Leg pain (12-months) | \*OR 1.57 [0.65-3.91] | age, sex, smoking, activity participation, smoking, and mental health status | No association |
| No association. High growth spurt (>5cm in 6months), Ankle & Foot pain (12-months) | \*OR 1.37 [0.75-2.49] | age, sex, smoking, activity participation, smoking, and mental health status | No association |
| Picavet 2016 - Log Reg | No association. Upper 20% weight gain, Upper extremity complaint (3-years) | \*OR 1.10 [0.70-1.75] | Sex, age | No association |
| No association. Upper 20% weight gain, Lower extremity complaint (3-years) | \*OR 1.13 [0.80-1.59] | Sex, age | No association |
| No association. Upper 20% height gain, Upper extremity complaint (3-years) | \*OR 1.48 [0.92-2.39] | Sex, age | No association |
| No association. Upper 20% height gain, Lower extremity complaint (3-years) | \*OR 1.09 [0.75-1.58] | Sex, age | No association |
| Rate | Hulsegge 2011 - Imp Reg | No association. Height growth (cm/year), Lower extremity complaint (3-years) | OR 1.05 [0.93-1.18] |  | No association |
| ↑Weight growth (kg/year), ↑lower extremity complaints (3-years) | \*OR 1.16 [1.05-1.29] | age, sex, physical activity, daytime tiredness, mental health status | Positive |
| No association. Height growth (cm/year), Upper extremity complaint (3-years) | OR 1.02 [0.86-1.22] |  | No association |
| No association. Weight growth (kg/year), Upper extremity complaint (3-years) | OR 1.04 [0.88-1.22] |  | No association |
| **Cross-sectional associations between biological maturity and back, neck or extremity pain, or any report of MSK pain** | | | | | | |
| **Pain type** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Back Pain | Status | Dolphens 2016 - Log Reg | No association. Maturity status (early vs average maturers; method undefined), LBP | \*OR 1.83 [0.38–8.72] | Physical characteristics, sociodemographic, lifestyle factors, psychosocial characteristics, and other pain complaints | No association |
| No association. Maturity status (late vs average maturers; method undefined), LBP | \*OR 1.15 [0.16–8.15] | Physical characteristics, sociodemographic, lifestyle factors, psychosocial characteristics, and other pain complaints | No association |
| Hulsegge 2011 - Imp Reg | No association. PDS, back complaints | OR 1.23 [0.77-1.96] |  | No association |
| Boys: ↑PDS score, ↑back complaints | OR 2.86 [1.14-7.15] |  | Positive |
| Girls: No association. PDS, back complaints | OR 1.09 [0.65-1.84] |  | No association |
| Jones 2005 - Log Reg | No association. Genital development, Recurrent NSLBP | controls 3.3[0.9] vs. recurrent-LBP 3.7[0.7] |  | No association |
| No association. Pubic hair staging, Recurrent NSLBP | controls 3.2[0.7] vs. recurrent-LBP 3.6[0.7] |  | No association |
| LeResche 2005 - Log Reg | Boys: ↑PDS score, ↑%back pain | OR 1.9 |  | Positive |
| Girls: ↑PDS score, ↑%back pain | OR 2.0 |  | Positive |
| Picavet 2016 - Log Reg | No association. PDS, Back complaint | \*OR 1.21 [0.92-1.59] | Sex, age | No association |
| Wedderkopp 2005 - Log Reg | Girls: Advancing pubertal stages (breast development), ↑back pain anywhere | Puberty stages 2 to 5 OR 1.1-2.6 |  | Positive |
| Girls: Advanced pubertal stages (breast development), ↑LBP | Puberty stages 2 to 5 OR 0.9-19.6 |  | Positive |
| Girls: No association. Pubertal stage (breast development), mid back pain | Puberty stage 2 to 5 OR 1.0-1.6 |  | No association |
| Timing | Dolphens 2016 - Log Reg | No association. Years from age at PHV, LBP | \*OR 1.42 [0.14–14.50] | Physical characteristics, sociodemographic, lifestyle factors, psychosocial characteristics, and other pain complaints | No association |
|
| No association. Predicted growth remaining, LBP | \*OR 1.04 [0.79–1.36] | Physical characteristics, sociodemographic, lifestyle factors, psychosocial characteristics, and other pain complaints | No association |
| Hulsegge 2011 - Imp Reg | No association. Height-for-age/sex based on reference growth curves, Back complaint | OR 1.08 [0.85-1.38] |  | No association |
| Picavet 2016 - Log Reg | No association. Height-for-age, Back complaint | \*OR 1.13 [0.98-1.30] | Sex, age | No association |
| ↑Weight-for-age, ↑Back complaints | \*OR 1.31 [1.12-1.53] | Sex, Age, Being bullied, Sleeping problems, Smoking (>1/mo), Back complaint at 11 years | Positive |
| Vikat 2000 - Log Reg | Earlier timing of puberty (age at menarche / first ejaculation), ↑%LBP | Early timing: OR 1.2 |  | Positive |
| Neck-shoulder | Status | Wedderkopp 2005 - Log Reg | Girls: No association. Pubertal stage (breast development), neck pain | Puberty stages 2 to 5 OR 0.5-1.2 |  | No association |
| Timing | Vikat 2000 - Log Reg | No association. Timing of puberty (age at menarche or first ejaculation), neck-shoulder pain ("best-fitting model") | early timing: \*OR 1.1 | sex, age, psychosomatic symptoms, LBP, long-term illness, cold, vision, smoking | No association |
| Extremity Pain | Status | Hirano 2001 – t-test | Boys: No association. Skeletal age, Disorder of the knee extensor mechanism | normal knees 12.99±1.89 years vs. painful knees 12.13±1.29 years |  | No association |
| Hulsegge 2011 - Imp Reg | Advanced pubertal status (PDS), ↑upper extremity complaints | OR 1.46 [1.03-2.05] |  | Positive |
| Advanced pubertal status (PDS), ↑lower extremity complaints | OR 1.45 [1.13-1.86] |  | Positive |
| Picavet 2016 - Log Reg | No association. PDS, Upper extremity complaint | \*OR 1.22 [0.91-1.63] | Sex, age | No association |
| No association. PDS, Lower extremity complaint | \*OR 1.04 [0.84-1.29] | Sex, age | No association |
| Timing | Hulsegge 2011 - Imp Reg | ↑Height-for-age scores, ↑lower extremity complaints | OR 1.16 [1.01-1.32] |  | Positive |
| No association. Height-for-age score, Upper extremity complaint | OR 1.16 [0.96-1.42] |  | No association |
| Picavet 2016 - Log Reg | No association. Height-for-age, Upper extremity complaint | \*OR 1.03 [0.88-1.19] | Sex, age | No association |
| ↑Height-for-age, ↑Lower extremity complaints | \*OR 1.13 [1.01-1.27] | Sex, age | Positive |
| No association. Weight-for-age, Upper extremity complaint | \*OR 1.16 [0.99-1.35] | Sex, age | No association |
| ↑Weight-for-age, ↑Lower extremity complaints | \*OR 1.15 [1.03-1.29] | Sex, age | Positive |
| MSK pains | Status | Hirsch 2012 - X2 | Later pubertal stage (PDS), ↑pain (outside the face) | \*OR 1.61 [1.21-2.13] | Gender, school type | Positive |
| Hulsegge 2011 - Imp Reg | Advanced pubertal status (PDS), ↑ any musculoskeletal complaints | \*OR 1.36 [1.09-1.70] | Weight-for-height z score, mental health status, daytime tiredness, physical activity | Positive |
| LeResche 2005 - Log Reg | Girls: ↑Level of puberty (PDS), ↑%one or more pains | \*OR 1.37 [1.12-1.68] | Child age, parent education | Positive |
| Boys: ↑Level of puberty (PDS), ↑%one or more pains | \*OR 1.37 [1.07-1.75] | Child age, parent education | Positive |
| Picavet 2016 - Log Reg | No association. PDS, Any musculoskeletal complaint | \*OR 1.02 [0.86-1.22] | Sex, age | No association |
| Rhee 2005 - Log Reg | Boys: Advanced pubertal status, ↑musculoskeletal pain | \*OR 1.61 [1.37-1.89] | Sampling probability and design factors | Positive |
| Girls: Advanced pubertal status, ↑musculoskeletal pain | \*OR 1.50 [1.32-1.71] | Sampling probability and design factors | Positive |
| Sperotto 2014 - X2 | ↓Pubertal stage, ↑chronic musculoskeletal pain symptoms | Pre-pubertal 83.0% vs. Pubertal 17.0% |  | Negative |
| Sperotto 2015 -X2 | ↑Pubertal stage, ↑%Persistent musculoskeletal pain | Pre-pubertal -10% vs. Pubertal +4% |  | Positive |
| Timing | Hulsegge 2011 - Imp Reg | ↑height-for-age scores, ↑any musculoskeletal complaints | OR 1.15 [1.03-1.29] |  | Positive |
| Rhee 2005 - Log Reg | Boys: Early pubertal timing, ↑musculoskeletal pain | \*OR 1.41 [1.23-1.62] | Sampling probability and design factors | Positive |
| Girls: Early pubertal timing, ↑musculoskeletal pain | \*OR 1.29 [1.11-1.50] | Sampling probability and design factors | Positive |
| Picavet 2016 - Log Reg | No association. Height-for-age, Any musculoskeletal complaint | \*OR 1.10 [1.00-1.21] | Sex, age | No association |
| ↑Weight-for-age, ↑Any musculoskeletal complaint | \*OR 1.19 [1.08-1.31] | Sex, age | Positive |
| Kloven 2017 - Log Reg | Girls: Early menarche, ↑Chronic non-specific pain | \*OR 1.5 [1.2-1.9] | Age, BMI, parents’ combined income, both parents’ highest education, anxiety and depressive symptoms | Positive |
| Girls: Early physical maturation, ↑Chronic non-specific pain | \*OR 1.6 [1.3-1.9] | Age, BMI, parents’ combined income, both parents’ highest education, anxiety and depressive symptoms | Positive |
| Girls: Early menarcheal age, ↑Chronic non-specific pain | OR 0.84 [0.79-0.90] |  | Positive |
| **Prospective associations between biological maturity and head/face pain** | | | | | | |
| **Pain Type** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Head or face pain | Status | Dunn 2011 - LCGA | ↑PDS score, ↑%headache (3-years) | ↓%Headache PDS=2.04 vs. ↑%Headache PDS=2.02-2.29 |  | Positive |
| ↑PDS score, ↑%facial pain (3-years) | ↓%facial pain PDS=2.02 vs. ↑%fascial pain PDS=2.13-2.29 |  | Positive |
| Janssens 2011a - Ord Log Reg | No association. PDS, headache (2-3-years) | \*OR 1.07 [0.93-1.25] | Gender | No association |
| Girls: No association. PDS, headache (2-3-years) | OR 1.14 [0.95–1.37] |  | No association |
| Boys: No association. PDS, headache (2-3-years) | OR 0.96 [0.75–1.23] |  | No association |
| Janssens 2011b - Ord Log Reg | No association. PDS, headache (2-3-years) | \*OR 1.18 [0.94-1.48] | Gender | No association |
| Girls: No association. PDS, headache (2-3-years) | OR 1.24 [0.94–1.61] |  | No association |
| Boys: No association. PDS, headache (2-3-years) | OR 1.02 [0.66–1.59] |  | No association |
| Timing | Kröner-Herwig 2009 - Log Reg | Girls: Inconsistent association. Occurrence of menarche, headache (migraine, tension-type headache) (3-years) | OR 0.75 - 1.65 |  | No association |
| **Cross-sectional associations between biological maturity and head/face or chest pain** | | | | | | |
| **Pain Type** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Head or face | Status | Rhee 2005 - Log Reg | Boys: Advanced pubertal group, ↑ headaches | \*OR 1.14 [0.96-1.35] | Sampling probability and design factors | Positive |
|
| Girls: Advanced pubertal group, ↑ headaches | \*OR 1.78 [1.52-2.08] | Sampling probability and design factors | Positive |
| LeResche 2005 - Log Reg | Girls: ↑ pubertal stage (PDS), ↑%headache | OR 1.4 |  | Positive |
| Boys: No association. PDS, headache | OR 1.0 |  | No association |
| Girls: ↑pubertal stage (PDS), ↑%facial pain | OR 1.6 |  | Positive |
| Boys: ↑pubertal stage (PDS), ↑%facial pain | OR 1.5 |  | Positive |
| Hirsch 2012 - X2 | No association. PDS, temporomandibular pain | \*OR 1.13 [0.80-1.60] | Gender, school type | No association |
| Advanced pubertal stage (PDS), ↑ any TMD diagnosis | \*OR 1.58 [1.03-2.42] | Gender, school type | Positive |
| Advanced pubertal stage (PDS), ↑ IIa TMD diagnosis | \*OR 2.00 [1.21–3.26] | Gender, school type | Positive |
| No association. PDS, I/III TMD diagnoses | \*OR 0.74 [0.32–1.71] | Gender, school type | No association |
| Weiler 2010 - Fisher | Boys: No association. Pubertal status (Tanner), TMD | Before the growth spurt: no TMD 17% vs. ≥ one sign or symptom of TMD 12%; |  | No association |
| During growth spurt period: no TMD 70% vs. ≥ one sign or symptom of TMD 71%; |
| End of growth spurt: no s TMD 13% vs. ≥ one sign or symptom of TMD 18% |
| Timing | Aegidus 2011 - Log Reg | Girls: Late menarche (>12 years), ↓%Headache among adolescents | \*OR 0.8 [0.7–0.9] | age, body mass index, and for use of oral contraceptives | Positive |
| Girls: Late menarche (>12 years), ↓%Migraine among adolescents | \*OR 0.7 [0.5–0.9] | age, body mass index, and for use of oral contraceptives | Positive |
| Girls: Late menarche (>12 years), ↓%Tension type headache among adolescents | \*OR 0.8 [0.6–0.9] | age, body mass index, and for use of oral contraceptives | Positive |
| Girls: No association. Age at menarche, Non-classifiable headache among adolescents | \*OR 0.9 [0.6–1.2] | age, body mass index, and for use of oral contraceptives | No association |
| Rhee 2005 - Log Reg | Boys: No association. Pubertal timing, headache | late timing 20.56% vs. on-time=20.56% vs. early timing 21.28% | Sampling probability and design factors | No association |
| Girls: Early timing of puberty, ↑ headache | \*OR 1.39 [1.22-1.58] | Sampling probability and design factors | Positive |
| Deubner 1977 - X2 | Girls: No association. Menarchial status, Headache | pre- 78.5% vs. post- 84.2% menarche |  | No association |
| Girls: No association. Menarchial status, Migraine | pre- 21.5% vs. post- 15.8% menarche |  | No association |
| Chest pain | Status | Rhee 2005 - Log Reg | Boys: No association. Pubertal status, chest pain | early pubertal 3.36% vs. mid-pubertal 3.36% vs. advanced pubertal 3.01% | Sampling probability and design factors | No association |
| Girls: No association. Pubertal status, chest pain | early pubertal 4.43% vs. mid-pubertal 4.45% vs. advanced pubertal 5.04% | Sampling probability and design factors | No association |
| Timing | Rhee 2005 - Log Reg | Boys: No association. Pubertal timing, chest pain | late timing 3.61% vs. on-time 2.69% vs. early timing 3.66% | Sampling probability and design factors | No association |
| Girls: Late pubertal timing, ↑chest pain | \*OR 1.79 [1.25-2.57] | Sampling probability and design factors | Negative |
| **Prospective associations between biological maturity and sports injuries** | | | | | | |
| **Sports Injury** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Athletic injury | Timing | Fourchet 2011 - ANOVA | Boys: Late maturation (age at peak height velocity), ↑foot/ankle/lower leg injury rate (3-years) | Late maturity IR 1.3 [0.4-2.2] vs. Normal maturity IR 0.4 [-0.1-1.4] vs. Early maturity IR 0.5 [-1.0-1.5] |  | Negative |
|
| Tenforde 2013 – Descriptive & Cox Reg | Girls: No association. Age at menarche, Stress fracture (4-season) | Stress fracture 13.4[±1.5] vs. no stress fracture 12.6[±1.3] |  | No association |
| Girls: Late age at menarche (>15yrs), Stress fracture (4-season) | \*HR 2.49 [1.01-6.17] | Menstrual history, BMI, eating disorders, dietary intake of dairy and calcium, history of fracture, training variables, and prior sports participation | Negative |
| Football injury | Status | Linder 1995 - Fisher | Boys: ↑Maturity (Tanner stage), ↑Rate of football injury (2-season) | Stage I 0% vs. Stage II 3% vs. Stage III 16% vs. Stage IV 17% vs. Stage V 20% |  | Positive |
| Rochelle 1961 - t test | Boys: No association. Skeletal age, Football injury (1-season) | Non-injured 183 vs. Injured 185, difference 2.0 months, S.E. Diff. 4.84 |  | No association |
| Timing | Johnson 2009 - ANCOVA & Poisson Reg | Boys: No association. Maturity status (chronological age minus skeletal age), Soccer injury rate (6-yeasrs) | Late Maturity IR 1.4 [1.2-1.6] vs. Normal Maturity IR 1.5 [1.39-1.61] vs. Early Maturity IR 1.8 [1.59-2.0] |  | No association |
|
| Le Gall 2007 - Kruskal–Wallis & SNK | Boys: No association. Maturity status (skeletal age vs. chronological age), Soccer injury rate (10-seasons) | Early maturity IR 13.2 [9.3–17.6] vs. Normal maturity IR 12.3 [9.6–14.7] vs. Late maturity IR 6.5 [2.5–10.6] |  | No association |
| Boys: Early maturity (skeletal age vs. chronological age), ↑Soccer re-injury rate (10-seasons) | Early maturity IR 0.35 vs. Normal maturity IR 0.12 vs. Late maturity IR 0.08 |  | Positive |
| Boys: No association. Maturity status (skeletal age vs. chronological age), Moderate severity soccer injury rate (10-seasons) | Early maturity IR 1.7 vs. Normal maturity IR 2.0 vs. Late Maturity IR 0.6 |  | No association |
| Boys: Late maturity (skeletal age vs. chronological age), ↑Severe soccer injury (10-seasons) | Early maturity IR 0.3 vs. Normal maturity IR 0.6 vs. Late maturity IR 0.9 |  | Negative |
| Malina 2006 -MANCOVA | No association. Percentage of predicted mature height, Football injury (2-seasons) | Mean maturity z-score: non-injured 0.28-0.73 vs. injured 0.06-0.69 | age | No association |
| van der Sluis 2014 - ANOVA | Boys: Period of PHV, ↑N traumatic injuries (3-years) | Pre-PHV 0.81 [±1.10] vs. PHV 1.42 [±1.33] vs. Post-PHV 1.39 [±1.50] |  | Positive |
| Boys: No association. Maturity, N overuse injuries (3-years) | Pre-PHV 0.81 [±1.41] vs. PHV 1.15 [±1.29] vs. Post-PHV 1.42 [±1.50] |  | No association |
| Boys: No association. Maturity, N missed days (3-years) | Pre-PHV 7.27 [±10.05] vs. PHV 15.69 [±19.93] vs. Post-PHV 10.73 [±17.77] |  | No association |
| Boys: No association. Maturity, training IR (3-years) | Pre-PHV 2.57 [±3.22] vs. PHV 4.19 [±4.13] vs. Post-PHV 3.84 [±3.48] |  | No association |
| Boys: No association. Maturity, training IR (time loss) (3-years) | Pre-PHV 1.59 [±2.04] vs. PHV 2.80 [±3.28] vs. Post-PHV 1.86 [±2.41] |  | No association |
| Boys: No association. Maturity, match IR (3-years) | Pre-PHV 12.49 [±26.06] vs. PHV 20.50 [±28.00] vs. Post-PHV 23.08 [±28.80] |  | No association |
| Boys: No association. Maturity, match IR (time loss) (3-years) | Pre-PHV 9.43 [±19.06] vs. PHV 11.77 [±19.86] vs. Post-PHV 15.91 [±21.03] |  | No association |
| van der Sluis 2015 -Mann-Whitney | Boys: No association. Maturity, traumatic injury pre-PHV (3-years) | IR 1.14 [±1.97] vs. 2.33 [±3.40] |  | No association |
| Boys: No association. Maturity, traumatic injury at PHV (3-years) | IR 3.14 [±3.52] vs. 3.96 [±2.57] |  | No association |
| Boys: No association. Maturity, traumatic injury post-PHV (3-years) | IR 2.95 [±3.59] vs. 2.97 [±3.74] |  | No association |
| Boys: Late maturity, ↑overuse injury pre-PHV (3-years) | IR 0.49 [±0.94] vs. 3.53 [±4.63] |  | Negative |
| Boys: Late maturity, ↑overuse injury at PHV (3-years) | IR 1.56 [±1.92] vs. 3.97 [±3.11] |  | Negative |
| Boys: No association. Maturity, overuse injury post-PHV (3-years) | IR 2.73 [±3.84] vs. 3.60 [±2.73] |  | No association |
| Gymnastics injury | Status | Caine 1989 - Discrim | Girls: No association. Sexual maturity (Tanner stage), Gymnastics injury rate (1-year) | Stage one IR 2.27-2.54 vs. Stage 2-3 IR 4.17-5.22 |  | No association |
| Girls: ↑Sexual maturity (Tanner stage), ↑Gymnastics injury severity (% time-loss injuries) (1-year) | Stage one 14.9%-15.5% vs. Stages two-to-three 28.5%-36.6% |  | Positive |
| Handball injury | Status | Mónaco 2015 - Descriptive & MANOVA | Boys: No association. Testicular volume (cm3), Overall IR (2-seasons) | \*IR6-10cm³ 8.6 vs. IR10-15cm³ 5.8 vs. IR20-25cm³ 5.3 | Age, Category, Tanner stage, Δtanner stage, Testicular volume, Pubertal Stage | No association |
| Boys: No association. Tanner Stage, Overall IR (2-seasons) | \*IRG2 4.5 vs. IRG3 6.5 vs. IRG4 5.6 vs. IRG5 5.3 | Age, Category, Tanner stage, Δtanner stage, Testicular volume, Pubertal Stage | No association |
| Boys: Unclear. Bone age, Overall IR (2-seasons) | IRSlow(<1) 2.9 vs. IRNormal 5.1 vs. IRAdvanced(>1) 6.1 |  | No association |
| Boys: No association. Pubertal stage, Overall IR (2-seasons) | \*IRP2 7.0 vs. IRP3 6.2 vs. IRP4 5.4 | Age, Category, Tanner stage, Δtanner stage, Testicular volume, Pubertal Stage | No association |
| Boys: No association. Change in Tanner Stage, Overall IR (2-seasons) | \*IR0 4.3 vs. IR1 6.5 vs. IR2 6 | Age, Category, Tanner stage, Δtanner stage, Testicular volume, Pubertal Stage | No association |
| Ice-hockey | Timing | Decloe 2014 - Poisson Reg | Girls (PeeWee): Early menarche, ↑Ice hockey injury rate (1-season) | \*IIR 4.1 [1.0-16.8] | Cluster (i.e. team) | Positive |
| Multisport injury | Status | Baxter-Jones 1993 - X2 | No association. Sexual maturity (Tanner stage), Sports injury rate (gymnastics, football (soccer), swimming, and tennis) (2-years) | Not reported |  | No association |
| No association. Sexual maturity (Tanner stage), Sports injury severity (gymnastics, football (soccer), swimming, and tennis) (2-years) | Not reported |  | No association |
| Timing | Rauh 2010 - t test | Girls: No association. Age at menarche, Multisport injury (1-season) | Uninjured 12.3±1.2 vs. Injured 12.6±1.2 |  | No association |
| Girls: No association Gynaecological age (chronological age minus age at menarche), Multisport injury (1-season) | Uninjured 3.4±1.7 vs. Injured 3.1±1.9 years |  | No association |
| **Prospective associations between growth and sports injuries** | | | | | | |
| **Sports Injury** | **Growth** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Football injury | Spurt | Kemper 2015 - Log Reg | Boys: ↑Growth of body height (≥ 0.6 cm/month), ↑Injury occurrence (1-season) | \*OR 1.63 [1.06–2.52] | Age | Positive |
| Boys: ↑Growth of BMI (> 0.3 kg/m2/month), ↑Injury occurrence (1-season) | \*OR 1.61 [1.04–2.49] | Age | Positive |
| Handball injury | Rate | Mónaco 2015 - Descriptive & MANOVA | Boys: No association. Change in testicular volume (cm3), Overall IR (2-seasons) | IRΔ0-4 9.6 vs. IRΔ5-8 7.4 vs. IRΔ>8 4.7 |  | No association |
| Spurt | Boys: No association. Peak growth rate (cm/6-months), Overall IR (2-seasons) | IR0cm 4.7 vs. IR0.5-3cm 4.8 vs. IR4-6cm 5.5 |  | No association |
| **Cross-sectional associations between biological maturity and sports injuries** | | | | | | |
| **Sports injury** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Gymnastics injury | Status | DiFiori 1997 - Descriptive | No association. Skeletal age, Distal radial stress injury | Injury 11.1[±2.3] vs. Normal 10.9[±3.3] |  | No association |
| Organised physical activity | Timing | Costa 2017 – Log Reg | Girls: Higher maturity offset, ↑Injury | \*OR 2.1 [1.2-3.7] | Physical activity level | Positive |
| Costa 2017 - Gam Reg | Girls: Early maturity, ↑Injury rate | \*β -0.70 [-1.22, -0.19] | Physical activity level, bone age, maturity offset | Positive |
| Girls: ↑Bone age, ↑Injury rate | \*β 0.18 [0.04, 0.32] | Physical activity level, maturation level, maturity offset | Positive |
| Girls: Lower maturity offset, ↑Injury rate | \*β −0.21 [−0.39, −0. 16] | Physical activity level, maturation level, bone age | Negative |
| **Retrospective associations between biological maturity and sports injuries** | | | | | | |
| Athletic injury | Timing | Tenforde 2011 - t test | Girls: No association. Age at menarche, Running injury (14-months) | No injury 12.7±1.3 vs. Previous injury 12.7±1.3 |  | No association |
| **Prospective associations between biological maturity and ballet injuries** | | | | | | |
| **Injury** | **Maturity**  **/Growth** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Ballet injury | Status | Bowerman 2014 - Poisson Reg | No (trivial) association. Sexual maturity (Tanner scale), Ballet injury rate (6-months) | \*RR 1.06 [0.59-1.90] | gender, age, height, body mass, occurrence of menarche, and change in foot length | No association |
| Timing | Bowerman 2014 - Poisson Reg | Girls: No (trivial) association. Age at menarche, Ballet injury rate (6-months) | \*RR 1.03 [0.10-8.95] | gender, age, height, body mass, Tanner stage, change in foot length | No association |
| Spurt | Bowerman 2014 - Poisson Reg | No (unclear) association. Foot length growth (0.5cm), Ballet injury rate (6-months) | Right: \*RR 1.41 [0.93-2.13] Left: \*RR 1.37 [0.77-2.44] | gender, age, height, body mass, Tanner stage, occurrence of menarche | No association |
| **Retrospective associations between biological maturity and ballet injuries** | | | | | | |
| Ballet injury | Timing | Gamboa 2008 – t-test | Girls: No association. Age at menarche, Ballet Injury (5-year) | Non-injured 13.5±1.2 vs. Injured 13.0±1.5 |  | No association |
| **Prospective associations between biological maturity and stress fracture injuries** | | | | | | |
| **Injury** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Stress fracture | Timing | Field 2011 – Cox Reg | Girls: ↑Age at menarche, ↑Stress fracture (7-years) | \*HR 1.35 [1.12-1.63] | Family history, Activity, age BMI, low bone mineral density | Negative |
| Loud 2005 - GEE | Girls: No association. Age at menarche, stress fracture (2-years) | \*OR 0.99 [0.94-1.17] | age | No association |
| **Prospective associations between biological maturity and fractures** | | | | | | |
| **Fracture** | **Maturity** | **Article - Analysis** | **Association** | **Strength of Association** | **Adjusted for** | **Direction** |
| Past year | Status | Wren 2012 - Cox Reg | ↑Sexual maturation (Tanner stages 2-4), ↑Fracture risk (6-years) | HR 1.74 [1.32-2.29] |  | Positive |
| ↑Skeletal age (10-14 years), ↑Fracture risk (6-years) | HR 2.17 [1.65-2.85] |  | Positive |
| Past nine months | Timing | Lynch 2016 - Descriptive | No association. PHV, Fracture (9-months) | No fracture -1.24±1.2 years vs. fracture -1.12±1.5 years |  | No association |
| **Retrospective associations between biological maturity and fractures** | | | | | | |
| At 7-15 years | Status | Chevalley 2011 - Descriptive | Boys: No association. Sexual development (Tanner stage), Fracture history (7-15 years-of-age) | Without fracture: P2 (n=1), P3 (n=7), P4 (n=49), P5 (n=32). With fracture: P2 (4), P3 (n=6), P4 (n=44), P5 (n=33) |  | No association |
| Lifetime | Status | Cheng 2009 – Descriptive & ANOVA | No association. Sexual development (Tanner grade), Fraction history (lifetime) | No fracture P1=49%, P2=45%, P3=6%. Upper limb fracture P1=49%, P2=43%, P3=8%.Upper limb fracture at 8-14 years P1=50%, P2=40%, P3=10%. Other fracture P1=64%, P2=36%, P3=0% |  | No association |
| Farr 2011 - t test | Girls: ↑Maturity (Tanner stage), ↑prior fracture | Fracture 2.5±0.9 vs. without fracture 2.0±1.0 |  | Positive |
| Thandrayen 2011 - Descriptive | Black females at 10 years: No association. Skeletal maturity (Bone age), Fracture history (lifetime) | With fracture 9.8±0.88 years vs. without fracture 9.9±1.1 years |  | No association |
| Black females at 15 years: No association. Skeletal maturity (Bone age), Fracture history (lifetime) | With fracture 14.7±0.5 years vs. without fracture 14.7±0.62 years |  | No association |
| Black males at 10 years: No association. Skeletal maturity (Bone age), Fracture history (lifetime) | with fracture 9.9±0.76 years vs. without fracture 9.9±0.70 years |  | No association |
| Black males at 15 years: No association. Skeletal maturity, Fracture history (lifetime) | with fracture 14.73±1.16 years vs. without fracture 14.8±1.30 years |  | No association |
| White females at 10 years: No association. Skeletal maturity, Fracture history (lifetime) | with fracture 10.2 ±1.26 years vs. without fracture 10.0±1.24 years |  | No association |
| White females at 15 years: No association. Skeletal maturity, Fracture history (lifetime) | with fracture 14.8±0.48 years vs. without fracture 14.6±0.71 years |  | No association |
| White males at 10 years: No association. Skeletal maturity, Fracture history (lifetime) | with fracture 10.2±0.72 years vs. without fracture 10.1 ±0.66 years |  | No association |
| White males at 15 years: No association. Skeletal maturity, Fracture history (lifetime) | with fracture 15.8±0.86 years vs. without fracture 15.3±1.06 years |  | No association |
| Timing | Chevalley 2012 - Descriptive | Girls: Late maturation (age at menarche), ↑Fracture history (lifetime) | With fracture 13.45±1.11 years vs. without fracture 12.78±1.19 years |  | Negative |
| Cheng 2009 – Descriptive & ANOVA | No association. Age at menarche, Fracture history (lifetime) | No fracture 13.0[0.9] years vs. upper limb fracture 13.2[1.0] years vs. upper limb fracture at 8-14years 13.4[1.1] years vs. other fracture 12.9[0.7] years |  | No association |
| No association. Age at peak height estimate, Fracture history (lifetime) | No fracture 12.4[1.2] years vs. upper limb fracture 12.3[1.0] years vs. upper limb fracture at 8-14 years 12.3[1.1] vs. other fracture 12.3[1.3] |  | No association |
| Farr 2011 - t test | Girls: ↑Maturity (Maturity offset - Index of maturation), ↑prior fracture | Fracture -0.6±1.0 years vs. without fracture -1.2±1.0 years |  | Positive |
| Not defined | Timing | Kindblom 2006 – Log reg | Men: No association. Age at PHV, previous fracture | \*OR 1.08 [0.89–1.31] | radius areal bone mass density | No association |
| Men: No association. Age at PHV, previous upper limb fracture | \*OR 0.35 [0.00–8.77] | radius areal bone mass density | No association |
| Men: ↑Age at PHV, ↑%previous fracture | \*OR 1.19 [1.00–1.42] | age at bone analysis, height, weight, smoking status, physical activity, and calcium intake for osteopenia variables and for age at bone analysis for fractures | Negative |
| Men: ↑Age at PHV, ↑%Previous upper limb fracture | \*OR 1.39 [1.08–1.79] | age at bone analysis, height, weight, smoking status, physical activity, and calcium intake for osteopenia variables and for age at bone analysis for fractures | Negative |
| Darelid 2010 - Descriptive | Men: Coincided. Age at PHV (Years from peak height velocity estimate), ↑fracture incidence (period not defined) | Peak height velocity: -11years = 8 fractures\*; ≥11<-9years = 17 fractures\*; ≥9<-7years = 16 fractures\*; ≥7<-5years = 27 fractures\*; ≥5<-3years = 31 fractures\*; ≥3<-1years = 42 fractures\*; +/-1years = 58 fractures\*; ≥1<3years = 24 fractures\*; ≥3<5years = 10 fractures\*; ≥5years = 2 fractures |  | Positive |

Abbreviations: ANCOVA Analysis of covariance; ANOVA Analysis of variance; BMI Body mass index; CM Centimetre; Cox Reg Cox regression; Fisher Fisher exact test; Gam Reg Gamma Regression; GEE Generalised estimating equation; HR Hazard ratio; IIR Injury incidence rate; Imp Reg Imputation Regression; IR Injury rate; KG Kilogram; LBP Low back pain; LCGA Latent class growth analysis; Log Reg Logistic regression; M Meter; MANCOVA Multivariate analysis of covariance; MSK musculoskeletal; MTH Month; N Number; NSLBP Non-specific low back pain; OR Odds ratio; Ord Log Reg Ordinal logistic regression; PDS Pubertal Development Scale; PHV Peak height velocity; SNK Student–Newman–Keuls test; TMD Temporomandibular disorder.