This section features a recent systematic review which is indexed on PEDro, the Physiotherapy Evidence Database (http://www.pedro.org.au). PEDro is a free, web-based database of evidence relevant to physiotherapy.

Effects of resistance training in children and adolescents: a meta-analysis

► **Behringer M,** vom Heede A, Yue Z, *et al*. *Pediatrics* 2010;**126**:1199–210.

BACKGROUND There is emerging consensus that resistance training is safe and effective during all stages of childhood and adolescence. Little is known, however, about the influence of age and maturity on strength gains. In particular, it is not clear whether the onset of puberty, with its rapid increase in sex hormones corresponds to an increase in the response to strength training.

AIM The authors aimed to synthesise the best available evidence to determine whether resistance training programmes are effective in children and adolescents as well as to examine the influence of age, maturity and programme parameters on strength gains.

SEARCHES AND INCLUSION CRITERIA Six biomedical databases were searched from their inception until August 2009. Authors searched key journals and reference lists as well as grey literature (eg, conference proceedings, published abstracts and books). Controlled studies reporting on the effects of resistance training on muscular strength in healthy males and females younger than 18 years were included. The Physiotherapy Evidence Database (PEDro) scale was used to assess the methodological quality of the included studies.

INTERVENTIONS Resistance training (weight training) was defined as exercise that requires the musculature to contract against resistance (eg, body weight, barbells). Resistance training programmes were described with respect to duration, frequency, intensity, volume and type of exercise (anisometric (anisometric: a dynamic contraction where the tension varies throughout the range of motion, eg, resistance machines or free weights), isokinetic, isometric).

MAIN OUTCOME MEASURE The main outcome was the difference in strength gain between the intervention and control groups expressed as percentage improvement from baseline.

STATISTICAL METHODS Random effects meta-analysis was performed to pool the results of the included studies and generate a weighted mean effect size (ES). Variability of training effects between studies was assessed using moderator/meta-regression analysis for a number of variables (gender, maturity, training type and resistance type, age, training frequency/week and mean intensity).

RESULTS Forty-two studies (n=1728 participants) were included in the meta-analysis. The PEDro scores of the included studies ranged from 2 of 10 to 7 of 10 (mean 4.9±1). The mean age of subjects was 11.5 years (SD 2.6 years) and 67% of participants were male. There was a large variation in the training period (range 4–60 weeks) but greater consistency in terms of duration (41.1 ± 12.3 min), frequency (2.7±0.8 sessions/week), intensity (60–80% of 1RM), volume (average 2–3 sets, 8–15 repetitions, 6–8 exercises) and type of exercise (83% anisometric, 7% isokinetic, 10% isometric).

The meta-analysis reported a weighted mean ES of 1.12 (SE 0.11). This indicates that on average, the strength of the training groups improved 1.1 SDs more than the control groups. Larger strength gains were associated with increasing maturity, increased volume (number of sessions/week) and a longer programme. Age, gender, number of sets and programme intensity did not influence the extent of strength gain (table 1).

Table 1 The influence of subject characteristics and training parameters on strength gains

Variable	n	Effect size (SE) by subgroup or correlation between characteristic and effect size	p
Subject characteristics			
Maturity			0.01
Prepubertal	282	0.81 (0.18)	
Intra/postpubertal	271	1.91 (0.41)	
Age	1728	r=0.21	0.10
Gender			0.41
Male	1162	1.08	
Female	317	1.42	
Training parameters			
Duration	Unclear	r=0.28	0.02
Sessions/week	Unclear	r=0.26	0.03
Sets	Unclear	r=0.14	0.36
Volume (sets × repetitions)	Unclear	r=0.07	0.64

LIMITATIONS/CONSIDERATIONS The authors performed a thorough search, addressed publication and reporting bias by including grey literature and reports in both English and German and used the PEDro scale to appraise the quality of included studies. Although the authors provided extensive definitions of maturation status and resistance training, they provided few details as to the primary outcome. Although the study reports significant increases in strength due to resistance training (ES 1.12), some caution is needed given the inclusion of non-randomised studies, which increases the risk of bias in the meta-analysis. The ES reported is not readily interpreted in terms of a percentage strength gain. As such, clinicians are unable to estimate the magnitude of benefit a strength training programme is likely to have. Furthermore, many of the moderator/meta-regression analyses were conducted on small samples due to inadequate reporting in the included studies. Thus, the findings should be interpreted with caution.

CLINICAL IMPLICATIONS Strength training is effective in children and adolescents. Maturity, as defined by pubertal stage (rather than age), is important in determining the size of the training effect. These findings suggest that larger strength gains can be expected in children after the onset of puberty.

Zoe A Michaleff, Steven J Kamper

The George Institute for Global Health, The University of Sydney, Sydney, Australia

Correspondence to Zoe Michaleff, The George Institute for Global Health, The University of Sydney, Sydney, Australia; zmichaleff@georgeinstitute.org.au

Competing interests None.

Provenance and peer review Commissioned; not externally peer reviewed.

Contributors ZAM and SJK selected the systematic review, interpreted the data, wrote the manuscript and are guarantors.

Accepted 4 May 2011
Published Online First 2 June 2011

Br J Sports Med 2011;**45**:755. doi:10.1136/bjsports-2011-090170