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INPLASY

The effects of unstable surface training on balance ability in healthy children and adolescents: A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

Support - No support.

Review stage at the time of initial registration - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 13 November 2026 and was last updated on 13 November 2026.

INTRODUCTION

Review question / Objective To quantify the effects of unstable surface training on balance ability in healthy children and adolescents through a systematic review and meta-analysis of randomized controlled trials (PICOS): Population — healthy children and adolescents aged 6-18 years without diagnosed disease, injury history or developmental disorders; Intervention — training performed primarily on unstable surfaces (balance pads, BOSU balls, Swiss balls, suspension straps, wobble boards), alone or as part of a combined programme; Comparator — stable-surface training, regular physical education/training, or no intervention; Outcomes — balance ability indices (functional tests: YBT/SEBT reach distances, Stork and single-leg stance maintenance time; force-platform indices: centre-of-pressure displacement, path length and sway index); Study design — randomized controlled trials only. Secondary objectives were to examine the moderating roles of age and comparator type on training effects.

Condition being studied Balance ability (static and dynamic postural control) in healthy children and adolescents. Balance is one of the three pillars of fundamental movement skills and underpins daily activity, sports participation and injury prevention. Postural control matures throughout childhood and adolescence, with adult-like sensory integration emerging only around 12 years of age. Unstable surface training is widely used in youth conditioning, but its effect on balance in this population, and whether surface instability itself adds benefit over the same exercises on stable surfaces, remains unclear.

METHODS

Participant or population Healthy children and adolescents aged 6–18 years (both sexes, any training status). Individuals with diagnosed disease, injury history or developmental disorders, adults, and patient populations are excluded.

Intervention Exercise training in which the main training content is performed on unstable surfaces

or devices (e.g., balance pads, BOSU balls, Swiss balls, suspension straps, wobble boards), delivered either as standalone training or as part of a combined programme, with no restriction on programme length, frequency or session duration.

Comparator Stable-surface training of similar content, regular physical education or training, or no intervention.

Study designs to be included Randomized controlled trials (RCTs) only. Non-randomized or quasi-experimental designs, single-group pre–post studies, cross-sectional studies, reviews, conference abstracts and other non-original research are excluded.Randomized controlled trials (RCTs) only. Non-randomized or quasi-experimental designs, single-group pre–post studies, cross-sectional studies, reviews, conference abstracts and other non-original research are excluded.

Eligibility criteria Studies must report at least one quantitative balance outcome (functional tests such as YBT/SEBT reach distances or stance maintenance time, or force-platform indices such as CoP displacement, path length or sway index) and report, or permit derivation of, means and standard deviations. Excluded: non-randomized designs; adults or patient populations; no balance outcomes; insufficient data; reviews, conference abstracts or other non-original research.

Information sources PubMed, Web of Science, the Cochrane Library, Embase, SPORTDiscus, the China National Knowledge Infrastructure (CNKI) and Wanfang Data were searched from database inception to January 2026. English search terms: ("unstable surface" OR instability OR "balance pad" OR BOSU OR "Swiss ball" OR "wobble board" OR suspension) AND (child* OR adolescen* OR youth) AND (balance OR "postural stability" OR "postural control"); equivalent Chinese terms were used in CNKI and Wanfang. Authors of included studies were contacted for additional data where necessary.

Main outcome(s) Balance outcomes measured post-intervention: (1) functional tests — Y-balance test (YBT) and star excursion balance test (SEBT) reach distances (anterior, posteromedial, posterolateral), and Stork/single-leg stance maintenance time; (2) force-platform indices — centre-of-pressure (CoP) displacement, path length and sway index. Outcomes are analysed within four domains: static balance maintenance time, CoP displacement, dynamic balance maintenance time, and reach distance. Effect measure: standardized mean difference (Hedges' g) with 95% confidence intervals versus control.

Quality assessment / Risk of bias analysis Risk of bias is assessed with the Cochrane RoB 2.0 tool across five domains (randomization process; deviations from intended interventions; missing outcome data; measurement of the outcome; selection of the reported result). Overall judgement: low risk if all domains are low risk; some concerns if at least one domain raises some concerns and none is high risk; high risk if any domain is at high risk. Methodological quality is additionally rated with the PEDro scale (10 scored items, 0–10). Certainty of evidence per outcome is graded using GRADE (GRADEpro GDT). Two reviewers assess independently; discrepancies are resolved by consensus or a third reviewer.

Strategy of data synthesis Analyses are performed in R (version 4.3.1). Standardized mean differences (Hedges' g) with 95% confidence intervals are pooled using random-effects models; heterogeneity is evaluated with the Q test and I^2 statistic. Change-score SDs are estimated as $SD_{change} = \sqrt{(SD_{pre}^2 + SD_{post}^2 - 2r \times SD_{pre} \times SD_{post})}$ with $r = 0.5$ in the primary analysis. For multi-arm trials sharing a control group, the control-group sample size is split. Meta-regression explores the dose–response relationship with total training sessions (weeks × weekly frequency). Publication bias is assessed with Egger's linear regression and Begg's rank correlation tests. Statistical significance is set at $p < 0.05$; reporting follows PRISMA 2020.

Subgroup analysis Pre-specified subgroup analyses: (1) comparator type — class A (unstable- versus stable-surface training, isolating the effect of surface instability) versus class B (unstable-type versus conventional training or physical education); (2) age — children (<12 years) versus adolescents (≥12 years); (3) dose — low-dose (≤16 sessions) versus high-dose (≥18 sessions), split at the natural break in the distribution of total training sessions. Subgroup differences are tested using the Q statistic.

Sensitivity analysis Leave-one-out analyses for all pooled outcomes to examine the influence of individual studies; re-analysis of change-score SDs using alternative pre–post correlations ($r = 0.3$ and $r = 0.7$; primary analysis $r = 0.5$).

Country(ies) involved China.

Keywords unstable surface; balance training; children; adolescents; meta-analysis.

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