The Efficacy of Nonsurgical Interventions for Pediatric Flexible Flat Foot: A Critical Review

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Background: The pediatric flat foot frequently presents as a common parental concern in the health care setting. Foot orthoses are often used, yet benefits are uncertain and disputed, having been variably investigated. A recent Cochrane review cites limited evidence for nonsurgical interventions. This critical and structured review evaluates the effect of pediatric foot orthoses from assessment of the current literature.

Methods: A systematic search of the following electronic databases: Medline, CINAHL, AMED, and SPORTDiscus, using an array of search terms. A further search was also performed on relevant reference listings. Inclusion criteria were peer-reviewed journal articles, publication date from 1970 onwards, in the English language. Exclusion criteria were surgery interventions, adult subjects, rigid flat foot, articles based on opinion. A structured Quality Index was used to evaluate the research quality of articles. Three reviewers independently assessed the studies with disputes resolved by majority consensus. Studies were then grouped according to the outcome measures used.

Results: Thirteen articles, from an initial 429, met the criteria for quality evaluation. The mean Quality Index score was 35% (range: 13% to 81%), indicative of generally poor and varying methodological quality.

Conclusions: The low quality of the studies negates definitive conclusions. Only 3/13 quality evaluations scored > 50%; hence, evidence for efficacy of nonsurgical interventions for flexible pediatric flat feet is very limited. Future research needs validated foot type assessment, applicable outcome measures for the intervention, the use of control groups, allowance for independent effects of footwear, age range comparisons, larger samples, and prospective, longer follow-up.

Clinical Relevance: There is very limited evidence for the efficacy of nonsurgical interventions for children with flexible flat feet. Clinicians need to consider the lack of good-quality evidence in their decision-making for the management of pediatric flat foot.

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Pediatric flat foot continues to be a frequent presentation to a range of health professionals, as it remains a common concern to parents.[1,2] A recent Cochrane review, and a subsequent wider topic review, has highlighted the limited evidence relating to the use of foot orthoses, which are commonly used by clinicians for treating pediatric flat foot.[3,4] Cochrane reviews are central to evidence-based medicine. However, by focusing exclusively on randomized controlled trials (RCTs) a large swath of the published literature is excluded from general purview. Our experience, conducting 2 published reviews that examined interventions for pediatric flat feet, has brought particular methodological issues to light,[3,4] which in turn, contribute to the benefits of treatment being disputed, and the conclusions about studies addressing intervention effects, becoming polarized.[5–11]

The aim of this literature review was to evaluate the effect of foot orthoses on the flexible pediatric flat foot, and using a structured critical framework, to assess the methodological quality of the reported studies.

METHODS

Data Sources

A systematic search of electronic databases included Medline, CINAHL, AMED, and SPORTDiscus. The following search terms were used: flatfoot; flatfeet; flat foot; flat feet; pes planus; planovalgus; pronat* foot; pronat* feet; hyperpronat* feet; hyperpronat* foot; child*; pediatric*; infant*; adolescen*; teenag*; juvenile*; study; studies; trial; research; conservative; treat*; manage*; intervention; insole; insert; orthoses; orthotic*; footwear; shoe*; therapy; and rehabilitati*. The last electronic search was run on March 30, 2011. In addition, a secondary search was performed on the reference sections of the relevant articles.

Study Selection

The inclusion criteria were: peer-reviewed journal articles, publication date from 1970 to April 2011, participant sample size of > 1, and published in the English language. Articles based on expert opinion and clinical practice guidelines, despite their valued contribution, were

not reviewed as the purpose of this review is to establish the research evidence surrounding pediatric flexible flat foot, thereby providing an evidence base for clinical practice and identifying areas that require further research.[12] Exclusion criteria were articles with surgery as an intervention, participants that included adults (older than 18 y) or rigid flat foot in their sample and articles based on expert or consensus of opinion.

Data Extraction

All articles accepted for review underwent methodological assessment to evaluate the research quality. This process was performed using the Quality Index (QI), as described by Downs and Black,[13] which uses a structured checklist to assess the internal and external validity of clinical trials. The checklist was adjusted to exclude questions found to be less relevant that is, question 27 was excluded from evaluation of all studies and questions 9, 17, 19, 26 were excluded from the evaluation of the 5 cross-sectional studies. Three reviewers independently assessed the studies. In the instance of dispute, consensus was reached by majority decision. After assessment of methodological quality, articles were grouped to enable discussion according to outcome measures.

RESULTS

The database search generated 429 articles for initial screening, from which 13 articles remained for final inclusion. All included articles were published between 1972 and 2009.

The mean QI score for the articles was 35% (range: 13% to 81%), demonstrating variable and limited overall quality (Table 1). Considering the studies in terms of the methodological designs and the implicit levels of evidence,[14] demonstrates further disparity (Table 2). Three of the 13 studies did not use a control group or another intervention to compare the intervention effect.[15–17]

The methodological limitations common to all studies were: subjects not being representative of the recruited population (item 12); participants not blinded to the intervention (item 14); failure to use valid and reliable measures for the outcomes (item 20); and not concealing the randomized intervention assignment from patients and staff (item 24). In addition, the follow-up periods were disparate, ranging from no follow-up in the cross-sectional studies, to 4 years.[18] Sample sizes ranged broadly, from 8 to 637, and the recruitment age ranged from 7 months to 14 years. Various methods of diagnosing flat foot were used, with the most frequent being clinical observation of the arch. All of the studies included an intervention with some form of foot orthoses and footwear. Riccio et al[19] was the only study to evaluate the difference between a rehabilitative therapy program and foot orthoses with shoes. The majority of studies reported >1 outcome variable (Table 3). Radiographic parameters were used in 7 studies for which QI scores ranged from 15% to 55% (mean = 28%).[16,17,20–24] Six studies that reported the clinical assessment of static foot posture were reported as an outcome measure. Of these, most used the resting calcaneal stance position (RCSP) as the method of evaluation and the QI scores ranged from 13% to 56% (mean = 28%).[15,17,22,25,26] Two studies evaluated the effect of footwear and foot orthoses on the kinetics and kinematics of gait (QI: range 30% to 56%; mean = 43%)[25,27] and a further 2 studies evaluated the effect of interventions on pain (QI: range 30% to 81%; mean = 55%). Self-perception was evaluated in 1 RCT.[28]

DISCUSSION

From this critical review of the literature that has investigated the efficacy of nonsurgical interventions for pediatric flexible flat foot, it was found that the many outcome measures included: radiographs, static foot posture; kinetics and kinematics of gait; pain and function; and self-perception.

Radiographs were used to investigate the immediate effect of footwear, wedges and foot orthoses on radiographic parameters of the foot. Both studies utilizing radiographs found either found a nonsignificant difference between the groups,[23] which included a barefoot control,

TABLE 1. Quality Assessment of Included Articles

References	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Score	%
Riccio et al[19]	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	7/27	26
Whitford andEsterman[28]	1	1	1	1	2	1	1	0	1	1	1	0	1	0	1	1	1	1	1	0	1	1	1	0	1	1	22/27	81
Selby-Silverstein et al[25]	1	1	1	1	0	1	1	0	—	1	0	0	1	0	1	1	—	1	—	0	1	1	0	0	0	—	13/23	56
Leung et al[27]	1	1	0	1	0	1	1	0	—	0	0	0	1	0	0	0	—	0	—	0	1	0	0	0	0	—	7/23	30
Jay et al[15]	0	1	0	1	0	1	1	0	—	1	0	0	0	0	0	1	—	1	—	0	0	0	0	0	0	—	7/23	30
Capasso[22]	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	4/27	15
Gould et al[21]	1	1	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	8/27	30
Wenger et al[24]	1	1	1	1	1	1	1	0	0	1	1	0	1	0	1	0	0	1	0	0	1	1	1	0	0	0	15/27	55
Valmassy and Terrafranca[26]	0	1	0	1	0	0	0	0	—	0	0	0	0	0	0	1	—	0	—	0	0	0	0	0	0	—	3/23	13
Penneau et al[23]	1	1	1	1	0	0	1	0	—	0	0	0	0	0	0	1	—	0	—	0	0	0	0	0	0	—	6/23	26
Bordelon [16]	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	6/27	22
Bleck and Berzins[20]	0	1	1	1	1	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	11/27	41
Mereday et al[17]	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	8/27	30

The 3 assessors rated each publication, reaching consensus by majority in the instance of dispute.
Scoring system: 1 = yes; 0 = no/unable to determine; item 5: 2 = yes, 1 = partially, 0 = no.
From Downs and Black.[13]

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TABLE 2. Studies Examining Nonsurgical Interventions for Pediatric Flat Feet, Ranked According to the Levels of Evidence

Levels of Evidence	References	Findings and Recommendations			
1A = systematic review of RCTs	Rome et al[3]	There is limited evidence for the efficacy of nonsurgical interventions for flexible flat feet. Children with juvenile arthritis and foot pain benefit from customized foot orthoses			
	Wenger et al[24]	The impact of footwear should be considered when assessing pediatric gait and evaluating the effect of shoe or in shoe interventions			
		Age (y)	**Numbers**	**Interventions**	**Outcome Measures**
1B = RCTs with narrow confidence interval	Whitford and Esterman[28]	7-11	178	Over-the-counter FOs Custom-made FOs	Pain and function Self-perception
	Wenger et al[24]	1-6	129	Footwear Heel cup UCBL FOs	Radiographs
2 = cohort study/low-quality RCT	Riccio et al[19]	1.9-5	637	Muscle strengthening and stretching Shoe insert and footwear	Static foot posture
	Gould et al[21]	0.11-1.2	125	Footwear Footwear with arch cookies Footwear with long counters, solid shanks Thomas heels and medial heel wedges Footwear with additional thin arch support	Radiographs
	Bleck and Berzins[20]	1-12	71	Heel cup UCBL FOs Heel cup and UCBL FOs	Radiographs
3 = case-controlled study	Selby–Silverstein et al[25]	3-6	26	Athletic footwear Athletic footwear with custom-made FOs	Static foot posture Kinetics and kinematics
	Capasso[22]	2.1-8.3	51	Dynamic varus heel cup Simple insole	Radiographs Static foot posture
4 = case series, poor cohort case controlled	Leung et al[27]	4-11	8	Footwear Footwear with modified UCBL FOs	Kinetics and kinematics
	Valmassy and Terrafranca[26]	0.7-4.5	20	Barefoot Footwear Footwear with rearfoot wedge	Static foot posture
	Penneau et al[23]	1.5-4.5	10	Barefoot Footwear with medial heel wedge Footwear with over-the-counter FOs Footwear with UCBL FOs Footwear with FOs	Radiographs
	Mereday et al[17]	3.5-12	10	UCBL FOs	Radiographs Pain Static foot posture
	Bordelon[16]	3-9	22	Custom-made FOs	Radiographs
	Jay et al[15]	1.8-14	50	Dynamic stabilizing innersole system FOs	Static foot posture
5 = expert opinion		**Findings and Recommendations**			
	Harris et al[11]	Clinical practice guidelines based upon expert consensus, which directs flatfoot management according to diagnosis of subtypes and etiologies			
	Yeagerman et al[18]	The underlying cause of flat feet must be determined. No treatment is required for asymptomatic flexible flat feet. Painful flexible flat feet have many conservative treatment options. Conservative treatment may help rigid flat feet, but when this fails surgery is indicated and must be individualized. Treatment of flat feet is generally reserved for symptomatic cases, or those where wider factors (eg, family history, gait function) suggest increasing foot dysfunction over time			
	Evans[7]	Evidence-based, algorithmic pathway encompassing the Cochrane library systematic review and best available evidence to direct clinicians			

The disparate methodological quality of studies ranked within levels 1B to 4 is a notable limitation of the conclusions available.
FOs indicates foot orthoses; RCT, randomized controlled trials; UCBL, University of California Biomechanics Laboratory.

or found the difference to be minimal and possibly because of measurement error.[17] All studies that evaluated the effect of interventions over time on radiographic parameters found an improvement.[16,17,20–24] The results of Capasso[22] study also favored the group wearing the dynamic varus foot orthoses versus the simple insoles. Of the 7 studies, only 1 RCT[24] and 1 quasi-randomised controlled trial[21] investigated the difference between the groups over time and no significant difference was found between the groups and the controls.

Static measures of foot posture have been included in many studies. Riccio et al[19] used footprints only, whereas in addition to the RCSP, Capasso[22] evaluated the contour of the medial border of the foot, Jack test,

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TABLE 3. Quality of Articles Reporting Findings Based on Different Outcome Measures

Outcome Measures	Quality Index (%)		No. Studies
	Range	Mean	
Radiographs	15-55	28	7
Static foot posture	13-56	2	6
Kinetics and kinematics	30-56	43	2
Pain and function	30-81	55	2
Self-perception	—	81	1

formation of the arch when standing on tip toes, great toe alignment, and patella position and Mereday et al[17] measured the medial longitudinal arch height. The RCSP was assessed using the weight-bearing position of the calcaneus, either in relation to the ground or the lower leg. The position can then be subjectively evaluated or the angle measured in the frontal plane. Four studies evaluated the immediate effect of interventions on the RCSP of the supported foot and found an improvement.[15,17,25,26] A significant improvement was found with the Dynamic Stabilizing Innersole System foot orthoses,[15] and Selby-Silverstein et al[16] found a significant improvement after adjusting customized foot orthoses to correct the RCSP to vertical. Although high-topped shoes and triplanar wedges improved the number of degrees of correction of the RCSP, in the majority of participants in a study, it was not investigated if there was a significant improvement.[26] Two studies observed the effect of foot orthoses on the RCSP over time and found varying levels of improvement.[17,22] Capasso[22] subjectively evaluated the position of the calcaneus and found that both their interventions improved the RCSP over time with a higher percentage of improvement in the group wearing the dynamic varus insole versus the simple insole. Mereday et al[17] case series found an inclination towards improvement with the University of California Biomechanics Laboratory orthoses, however, results were inconclusive. Different methods of footprint analysis were used to evaluate the effect of different forms of foot orthoses and rehabilitative exercises.[19,22] All groups in both studies indicated an improvement with time. Riccio et al[19] was the only study to use rehabilitative treatment as an intervention and found this to be more effective in increasing the number of normal footprints over time. Capasso[22] evaluated the improvement over time with 4 different footprint methods; results based on percentages favoured the dynamic varus heel cup versus the simple insole. Neither study investigated the statistical difference between their groups. One case series evaluated the effect of foot orthoses on the medial longitudinal arch height.[17] This was evaluated using medial photographs of the foot using the calcaneus, navicular tuberosity, and base of the first metatarsal as landmarks to calculate an angle along the arch. Results indicated an immediate average improvement of 11.2 degrees when standing on the foot orthoses, however, no further statistical analysis was performed. The remaining parameters were evaluated by Capasso[22] and results favored the dynamic varus heel cup with an improvement in contour of the medial border of the foot, Jack test, formation of the arch when standing on tip toes, great toe alignment, and patella position. Results were based on percentages and no statistical comparison was made between the 2 groups.

Foot kinetics and kinematics were investigated in Selby-Silverstein et al's[25] study, which included participants with Down syndrome and a healthy comparison group, however, results focused on the Down syndrome participants, with minimal comparison made between the 2 groups. Both Selby-Silverstein et al[25] and Leung et al[27] found a significant decrease in foot abduction during gait. In addition, Leung et al[27] found a reduction in eversion of the calcaneus angle throughout gait, with the exception of heel strike. Results were reported as percentages, and the authors concluded that the foot orthoses controlled pronation of the foot enabling earlier resupination before propulsion, thereby potentially decreasing stresses through the foot and ankle. In addition, a significant reduction in the total rearfoot angular change, as measured by the angle between the calcaneus and the leg was found. This angle also significantly increased at the point of maximum eversion of the calcaneus. There were no differences in vertical force or heel eversion at heel strike, indicating that the foot orthoses did not alter shock absorption.

Pain and function was assessed in Whitford and Esterman's[28] randomized parallel single-blind trial that demonstrated the most robust methodology. Pain was measured using the child form of the Visual Analogue Scale.[29] Results indicated a significant improvement over time for pain, but no significant difference between the groups. Mereday et al[17] found that 6 out of 10 participants in their study who complained of pain before wearing University of California Biomechanics Laboratory foot orthoses, were all pain free during the 2-year trial time. Pain was evaluated using a questionnaire asking if they experienced pain during standing or walking. Whitford and Esterman[28] compared the effects of interventions on gross motor efficiency and exercise efficiency. Gross motor efficiency was measured using the Bruiniks Oseretsky Test,[30] which assesses running speed and agility, balance, coordination, and strength. Exercise efficiency was measured by a shuttle run test, which has been shown to be a valid predictor of maximal oxygen uptake.[31] As with pain, there was a small statistically significant change (not clinically significant) over time for both outcomes, but no significant changes between the treatment groups.

Self-perception has been evaluated in 1 study where it was indicated that there was a significant change over time for scholastic competence, social acceptance, and athletic competence, but no significant difference between the groups. There was no significant change over time or between the groups for physical appearance, behavioral conduct, and global self-worth.

CONCLUSIONS

The majority of the studies in this review used varying forms of foot orthoses, with and without footwear modifications, as the intervention. There is no evidence to

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indicate that orthopedic footwear, wedges, or foot orthoses immediately improve the radiograph parameters in children with flexible flat feet. The studies that evaluated the effect of intervention over time, on radiographic parameters, found no significant difference between the treatment groups. Many studies found an improvement over time in radiographic parameters and foot posture with all interventions. However, significant differences between groups were not investigated. As most studies did not include a control group, the normal physiological maturation of the arch cannot be ruled out.

Furthermore, as these outcome measures were static, it is unclear if or how the interventions affected gait. The effect of footwear with foot orthoses on gait was investigated and found a significant decrease in foot abduction but without control group comparisons, it is uncertain if any of these changes provide a functional change for children with flat feet.

Because of the heterogeneity and low methodological quality of the studies within this review, definitive conclusions cannot be drawn. Only 3 of the 13 studies evaluated surpassed a QI score of 50% and thus, there is very limited evidence for the efficacy of nonsurgical interventions for children with flexible flat feet.

Clinicians need to be aware of the lack of good-quality evidence in their decision-making for the management of pediatric flat foot.

Limitations and Recommendations for Future Research

Non-English language publications were not included in this review, which may omit findings of influence. Similarly, consensus statements and expert reviews were also excluded.

Future recommendations for research include the use of valid and reliable methods for classifying flat foot, and measuring outcomes which suitably assess the benefit of the intervention being tested.

Consideration must be given to the natural history of foot posture with age, emphasizing the need for control groups, comparative age ranges, and larger sample sizes.

Future studies need to further investigate the potential effect of rehabilitative exercises and continue to investigate the efficacy of foot orthoses, footwear modifications, and consider the effect of other contemporary clinical interventions.

Longer, prospective follow-up periods are required, to enable identification of intervention effect.

REFERENCES

1. Sullivan JA. Pediatric flatfoot: evaluation and management. *J Am Acad Orthop Surg*. 1999;7:44–53.
2. Garcia-Rodriguez A, Martin-Jimenez F, Carnero-Varo M, et al. Flexible flat feet in children: a real problem? *Pediatrics*. 1999;103:e84.
3. Rome K, Ashford RL, Evans AM. Non-surgical interventions for paediatric pes planus (Review). *Cochrane Database Syst Rev*. 2010;7 DOI:10.1002 /14651858.CD006311.pub2.
4. Evans AM, Rome KA. Cochrane review of the evidence for non-surgical interventions for flexible pediatric flat feet. *Eur J Phys Rehabil Med*. 2011;47:69–89.
5. Staheli LT. Planovalgus foot deformity. Current status. *J Am Podiatr Med Assoc*. 1999;89:94–99.
6. Pfeiffer M, Kotz R, Ledl T, et al. Prevalence of flat foot in preschool-aged children. *Pediatrics*. 2006;118:634–639.
7. Evans AM. The flat-footed child—to treat or not to treat, what is the clinician to do? *J Am Podiatr Med Assoc*. 2008;98:386–393.
8. D'Amico JC. The flat-footed child—to treat or not to treat: What is the clinician to do? Letter to the Editor. *J Am Podiatr Med Assoc*. 2009;99:267.
9. Bresnahan P. The Flat-Footed Child—To Treat or Not to Treat. What is the Clinician to Do? *J Am Podiatr Med Assoc*. 2009;99:178.
10. Harris EJ, Vanore JV, Thomas JL, et al. Diagnosis and treatment of pediatric flatfoot. *J Foot Ankle Surg*. 2004;43:341–373.
11. Harris EJ. The natural history and pathophysiology of flexible flatfoot. *Clin Podiatr Med Surg*. 2010;27:1–23.
12. Buchanan W, Kean WF. Clinical judgement and evidence-based medicine. *Joint Bone Spine*. 2001;68:370–372.
13. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiology Community Health*. 1998;52:377–384.
14. Sackett DL, Straus SE, Richardson WS, et al. *Evidence-Based Medicine. How to practice and teach EBM*. London: Churchill Livingstone; 2000.
15. Jay RM, Schoenhaus HD, Seymour C, et al. The Dynamic Stabilizing Innersole System (DSIS): the management of hyperpronation in children. *Journal of Foot & Ankle Surgery*. 1995;34:124–131.
16. Bordelon RL. Correction of hypermobile flatfoot in children by molded insert. *Foot Ankle*. 1980;1:143–150.
17. Mereday C, Dolan CM, Lusskin R. Evaluation of the University of California Biomechanics Laboratory shoe insert in "flexible" pes planus. *Clin Orthop Relat Res*. 1972;82:45–58.
18. Yeagerman SE, Cross MB, Positano R, et al. Evaluation and treatment of symptomatic pes planus. *Curr Opin Pediatr*. 2011; 23:60–67.
19. Riccio I, Gimigliano F, Porpora G, et al. Rehabilitative treatment in flexible flatfoot: a perspective cohort study. *Musculoskelet Surg*. 2009;93:101–107.
20. Bleck EE, Berzins UJ. Conservative management of pes valgus with plantar flexed talus, flexible. *Clinical Orthopedics & Related Research*. 1977;85–94.
21. Gould N, Moreland M, Alvarez R, et al. Development of the child's arch. *Foot Ankle*. 1989;9:241–245.
22. Capasso G. Dynamic varus heel cup: a new orthosis for treating pes planovalgus. *Ital.J.Orthop.Traumatol*. 1993;19:113–123.
23. Penneau K, Lutter LD, Winter RB. Pes planus radiographic changes with foot orthoses and shoes. *Foot & Ankle*. 1982;2:299–303.
24. Wenger DR, Mauldin D, Speck G, et al. Corrective shoes and inserts as treatment for flexible flatfoot in infants and children. *Journal of Bone & Joint Surgery—American Volume*. 1989;71:800–810.
25. Selby-Silverstein L, Hillstrom HJ, Palisano RJ. The effect of foot orthoses on standing foot posture and gait of young children with Down Syndrome. *NeuroRehabilitation*. 2001;16:193.
26. Valmassy RL, Terrafranca N. The Triplane Wedge. *J Am Podiatr Med Assoc*. 1986;76:672–675.
27. Leung AK, Mak AF, Evans JH. Biomedical gait evaluation of the immediate effect of orthotic treatment for flexible flat foot. *Prosthetics & Orthotics International*. 1998;22:25–34.
28. Whitford D, Esterman AA. randomized controlled trial of two types of in- shoe orthoses in children with flexible excess pronation of the feet. *Foot and Ankle International*. 2007;28:715–723.
29. Varni JW, Thompson KL, Hanson V. The Varni/Thompson Pediatric Pain Questionnaire. I. Chronic musculoskeletalpain in juvenile rheumatoid arthritis. *Pain*. 1987;28:27–38.
30. Wilson BN, Polatajko HJ, Kaplan BJ, et al. Use of the Bruinincks-Oseretsky Test of Motor Proficiency in Occupational Therapy. *Am J Occup Ther*. 1995;49:8–17.
31. Paliczka VJ, Nichols AK, Boreham CA. A multistage shuttle run as a predictor of running performance and maximum oxygen uptake in adults. *Br J Sports Med*. 1987;21:163–165.

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