PHYSICAL THERAPY INTERVENTIONSF OR LOW BONE MINERAL DENSITY IN CHILDREN WITH CEREBRAL PALSY: SYSTEMATIC REVIEW OF RANDOMIZED TRIALS

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Abstract

Background: Low bone mineral density in children with cerebral palsy (CP) can increase risk of fracture, chronic bone pain and it can result in a significant impact on quality of life; many interventions have been intended to improve low bone mineral density. **Aim of the study**: To systematically review the effect of physical therapy interventions on low bone mineral density in children with CP. **Methods:** Articles were identified through literature search using PubMed (MEDLINE), physiotherapy evidenced at abase (PEDro) and Cochrane database from 1999 up to December 2018 and through reference list of the included studies and library search at Faculty of Physical Therapy, Cairo University from July to December 2018.Studies were included if they were randomized trials focused on children with CP and low bone mineral density; treated with physical therapy intervention. Data from included studies was extracted and it smethodological quality was assessed using PEDro scale. The modified Sackett scale was used to assess level of evidence of each intervention. **Results:** Ten trials were identified with fair to good methodological quality. Studies were heterogeneous in regards to population characteristics, interventions or outcome measures; findings were qualitatively analyzed. There were strong evidence supporting the use of weight bearing and vibration; moderate evidence for magnetic and electro-therapy and suit therapy; while limited evidence about the use of virtual cycling to improve bone density in children with cerebral palsy.**Conclusion:** The present evidence supports the effectiveness of physical therapy interventions for improving bone mineral density in children with cerebral palsy.

Keywords: Bone Density-Cerebral palsy- Children -Systematic review.

Introduction

Children with disabilities including cerebral palsy (CP) are particularly vulnerable to deficits in bone mass due to decreased mobility and weight-bearing which reduces mechanical loading of the skeleton **[1, 2].**Cerebral palsy presents with "impairments" in body function and structure in addition to "activity" limitations and limited "participation" in social and community roles of the child **[3]**, many factors contribute to impaired bone health in children with CP include immobilization, malnutrition, muscle weakness, and the use of anticonvulsant drugs **[2]**.A strong relationship exists between bone strength and muscle force or size. The bone density of children with CP is adversely affected by abnormal modeling and remodeling due to decreased muscle strength during mechanical loading**[4].**Different interventions are used to improve bone mineral density (BMD) of children and adolescents with CP; that include medications and physical interventions**[5].**The purpose of this systematic review was to evaluate the effectiveness of physical therapy interventions to improve low mineral density in children with CP.

Methods

Search strategy

This study was based on the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement **[6].**

The electronic database search wasconductedfrom 1999toDecember 2018; of theCochrane Central Register of Controlled Trials (CENTRAL), the Physiotherapy Evidence Database (PEDro) and the PubMed databases.The following keywords were used: “Bone Density”, “Cerebral Palsy”, “Children”, “Interventions” “Physical therapy”, “Weight bearing”, “Standing”, “Electrical Field”, “Magnetic Field”, “Pulsed Ultrasound”“Suit Therapy”, “Vibration”, “Virtual cycling**”.** A manual search was also conducted of the reference lists of the relevant studies and the library of Faculty of Physical therapy of Cairo University from July to December 2018. Two independent reviewers evaluated the titles and abstracts of articles found in the searches according to theeligibility criteria.

Selection criteria

The studies were included in this review if theymet the following criteria: (1)**Participants:** childrenwith CPaged from 2 to 18 years, (2)**Interventions**:the study group received any physical intervention asweight bearing, standing, electrical or magnetic field, suit therapy, body vibration, virtual cycling; in isolation or in combination with other treatment interventions,(3)**Comparisons:**control, standard care or comparisons of different doses, intensities, or timing of the same intervention (4)**Outcomes**:Bone mineral density (primary outcome), muscle strength and gross motor functions (secondary outcomes),(5)**Study design:** randomized comparison or controlled trials. Review articles, survey, case report, case series andabstracts with no full text articles available were excluded.

Data Extraction

Data were extracted from the included studies by one reviewerand cross-checked by a second reviewer. Data extraction form **[7]** included authors and year of publication, study design, participant's characteristics, interventioncharacteristics and outcomes measures.

Quality assessment

The PEDro scale **[8]**was applied by two authorsindependently to assess trial quality and any disagreements were resolved by the third author.

Data analysis

For rating methodological quality, the following classification was used: a PEDro score of < 4 indicated poor quality; 4–5 fair quality; 6–8 good quality and 9–10 excellent quality**[9].** The modified Sackett scale was used to assess the level of evidence **[10]:**

-Level 1a (Strong)= Well-designed meta-analysis,or 2 or more 'high' quality RCTs (PEDro Scale scores ≥6) that show similar findings.

-Level 1b (Moderate)= One RCT of 'high' quality (PEDro Scale score ≥6).

-Level 2a (Limited) = At least one 'fair' quality RCT (PEDro Scale score=4-5).

-Level 2b (Limited)=At least one well-designed non-experimental study: non-RCT; quasi-experimental studies; cohort studies with multiple baselines; single subject series with multiple baselines

-Level 3 (Consensus)=Agreement by an expert panel, a group of professionals in the field or a number of pre-post design studies with similar results.

-Level 4 (Conflicting)=Conflicting evidence of two or more equally designed studies.

-Level 5 (No evidence)= No well-designed studies: "Poor" quality RCTs with PEDro scores ≤ 3; only case studies/case descriptions, or cohort studies/single subject series with no multiple baselines).

Results

Search results

The search results are presented in the PRISMA flow chart **[6]** in **Fig.1**. 23 studies were identified by the electronic and manual search. After removal of duplicates and screening titles and abstracts, 13full papers were retrieved. After being assessed against the inclusion criteria, 10 studies**[11-20]**were included in the review.

Characteristics of the included studies

A summary of the included studies is presented in **table 1**. The clinical heterogeneity between the included trials did not allow the quantitative analysis of data provided by these studies.

Qualitative analysis

Participants

Participants were 240 children with spastic CP, including both genders and ages between 2 and 13 years old. Six studies **[11, 14-17, 20]** investigated non-ambulant children who were able to stand alone with or without support. Three studies **[13, 18, 19]** investigated ambulant children with or without walking aids. The remaining study **[12]** investigated non-ambulant and ambulant children.

Interventions

The study group received standing programme with increased duration or intensity **[11, 16],** standing on vibrating platform **[20],** weight bearing program **[12],**home-based virtual cycling program**[13],**designed exercise program in addition to low intensity low frequency magnetic field therapy **[14];** or in addition to whole body vibration **[15, 19],** exercise program wearing a therapeutic suit **[17],** coupled electrical fields and low intensity pulsed ultrasound **[18].** The duration of intervention lasted from 1 to 9 months. The control group either just maintain their usualhabits and physical activity (2 studies **[12, 13]**) or receiveda designed physical therapy program (8 studies **[11, 14-20]**).

Outcome measures

-Bone mineral density(BMD) were assessed in all included studies; 8 studies **[12-19]**evaluated bone density by using Dual-Energy X-ray Absorptiometry (DEXA) at various anatomic sites, the other 2 studies **[11, 20]**used computed tomography (CT).

-Measure ofmuscle strength was reported in 2 studies **[13, 20]** using isokinetic dynamometer and curl up test. Trunk muscles, knee extensors and flexors, and calf muscle strength were assessed.

-Measure of gross motor function was reported in 2 study**[13, 19]**using the Gross Motor Function Measure (GMFM-66) and (GMFM-88).

Quality of the included studies and the level of evidence

The methodological quality of included studies is presented in **Table2**. The quality of studies ranged from good (7 studies**[11, 14-18,20]**) to fair **(3 studies[12, 13, 19]**) with a mean PEDro score of 6.3 out of 10 (range 5 to 8).All studies were randomised and one study **[20]** was a randomized cross-over study. The ten included studies had similar groups at baseline, analysed the between-group difference. All included studies except one**[19]**report < 15% loss to follow-up. Most of studies carry out an intention-to-treat analysis. Many studies did not conceal the allocation. Three studies **[11, 18, 20]**had blinded assessors, only one **[18]**had blinded participants and none of the studies blind therapists.

Evidence of physical therapy interventions

The results of the 10 included trials**[11-20]**which investigated effects of different physical therapy methods on bone density of children with CP are presented in **Table 3**.

Discussion

This review search collected the evidence of different physical therapy interventions used to improve bone density in children with CP; it revealed strong evidence forusing weight bearing and vibration; moderate evidence for magnetic and electro-therapy and suit therapy; and limited evidence about the effectiveness of virtual cycling in the management of low bone density of those children. This review aimed to use systematic methods for search and evaluation of the best available studies on the effect of physical therapy interventions for bone density children with CP, based on clinically relevant outcomes including BMD at different areas,muscle strength and gross motor function.

Hough et al **[21]** in 2010 performed a systematic review about interventions for low BMD in children with CP; it included only 3 trials of weight bearing. It was stated that finding effective evidence-based physical therapy interventions to improve bone density and decrease fracture incidence is critical for children with CP to have an optimal quality of life, the review revealed non-significant findings and recommended more needed RCTs for physical approaches.

The current review included 10 RCTs of various physical therapy interventions. Explanations were reported about the possible mechanismsby whichthese interventions improving bone density in children with CP; it was stated that weight bearing has combined effect of bone loading with muscle osteogenic signals which can reduce bone demineralization occurs with disuse **[8],** the vibration therapy was suggested to improve bone density through the mechanical stimulation that increasing blood circulation and activating osteoblasts while reducing osteoclasts activity **[15, 22].**

The capacitively coupled electric field and very low intensity pulsed ultrasound were reported to serve as exogenous alternates for the normal regulatory signals that restore bone's structural integrity and function in children with CP**[18, 23].** The magnetic field was suggested to enhance osteoblasts activities and inhibit osteoblastic differentiation **[14]**.

An indirect effect wassuggested as an explanation for suit therapy positive effect on bone density of children with diplegic CP through its influence on the surrounding musclesthat stimulate the underlying bone to increase mineralization **[17].** Finally, the virtual cycling training was reported to enhance lower limb bone in children with CP through the mechanical loading on bone induced by repetitive muscle contractions **[13].**

Moststudies **[12-19]**included in this review used DEXA for assessing BMD in children with CP; only two studies **[11, 20]**used CT. The sites tested were whole-body bone, lumbar spine, proximal and distal femoral and proximal tibial.

The current review highlights the variation in physical therapy interventions,its applications and duration in the included RCTs. This clinical heterogeneity limits the degree of comparison between the results of these studies and makes meta-analysis inappropriate.

Findings of this review support the effectiveness of using weight bearing exercises and vibration therapy as physical therapy interventions for children with CP. Magnetic and electro-therapy and suit therapy may be effective in improving BMD, but additional well-designed studies with larger sample sizes are still needed to confirm the present evidence.The limited evidence about the effectiveness of virtual cycling also needs further well-designed researches.

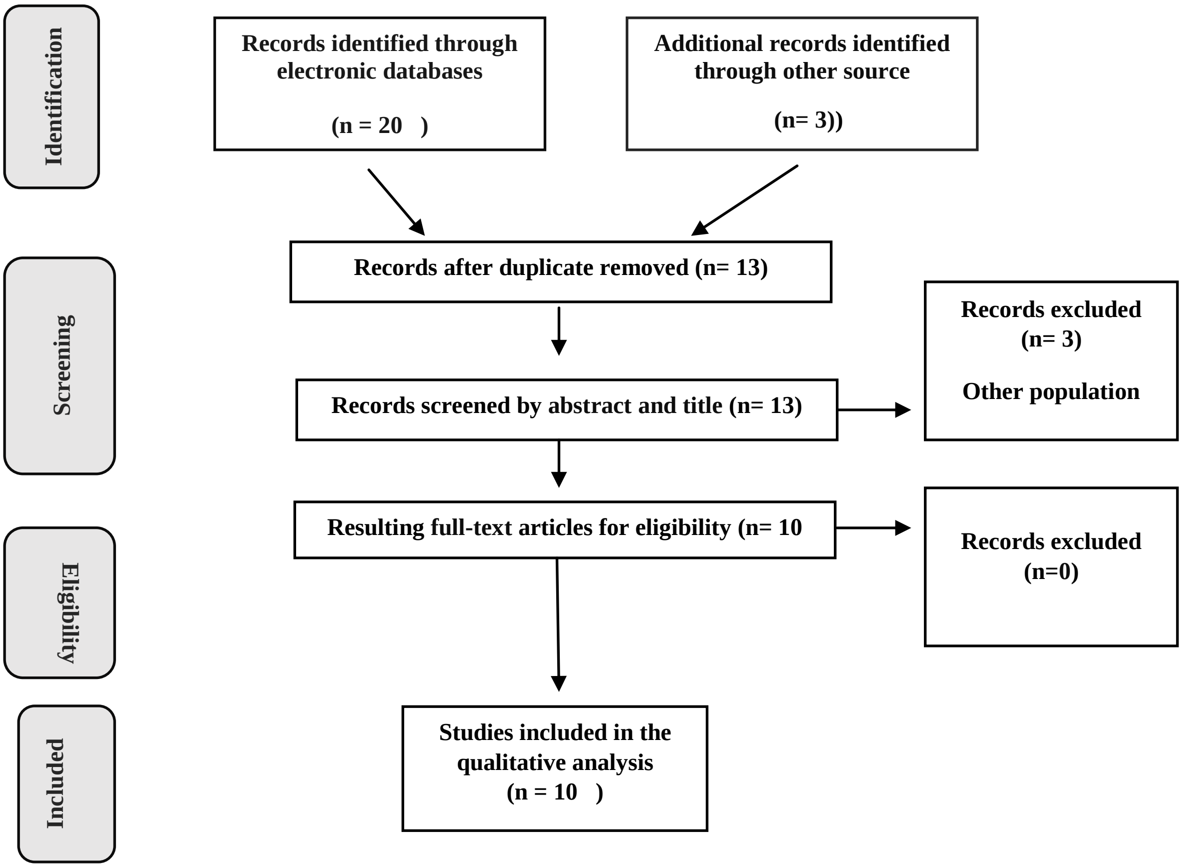

Figure 1: PRISMA flow chart of findings.

Table 1 Summary of included studies

Study	Participants	Intervention	Period of intervention	Outcome measures
Caulton et al (2004) [11]	• n = 26 • Mean age (range)= 7.3 yr (4.3- 10.8 yr) • Gender = 14 boys, 12 girls • Spastic CP (23 quadriplegia & 3 diplegia) • Non-ambulant	• Exp = 50% increase in regular standing duration • Con = no increase in regular standing duration. • Both = standing programme	• 9 months	• Vertebral & Proximal tibial bone mineral density (*v*TBMD)= 3D quantitative CT • Follow up= 0,9 months
Chad et al (1999) [12]	• n = 18 • Mean age = 9± 2.9 yr • Gender= 5 boys,13 girls • Spastic cerebral palsy (CP) • Ambulant & non-ambulant	• Exp= physical activity program(20 min upper extremities exercise & 20 min lower extremities exercise& 20 min truncal regionexercise) (1 hour x 2/wk x first 2months,3/wk x last 6 months) • Con= maintain usual lifestyle habits**.**	• 8 months	• Proximal femur & femoral neck bone mineral content (BMC) & volumetric bone mineral density (*v*BMD) = DEXA • Follow up = 0,8 months
Chen et al (2013) [13]	• n = 27 • Mean age (range) = 8.7 ±2.1 yr (6 to 12 yr) • Gender = 18boys, 9 girls • Spastic CP (19 diplegic, 8 hemiplegic) • GMFCS (21 level I,6 level II)	• Exp = Home-based virtual cycling training (hVCT), 40 min/day, 3/wk x 12 wk • Con = usual physical activities (walking, running, sports or recreational school or home activities), 30-40 min/day, 3/wk x 12 wk	• 3 months	• Lumbar (L1 to L4) & distal femoralBone Density= DEXA • Gross motor function= GMFM-66 • Abdominal muscle strength= curl up test • Knee extensors, flexorsstrength= isokinetic dynamometer • Follow up= 0,3 months
Eid et al (2008) [14]	• n = 20 • Mean age (range) = 4.75±0.79 yr (2 to 4 yr)	• Exp= low intensity low frequencymagneticfield therapy, 20 min • Con= designed exercise program based on NDT	• 3 months	• Femoral bone mineral density (BMD)=DEXA • Follow up = 0,3 months

	• Gender = 10boys, 10 girls • DDST >10 month	• 1.5 hour, 3/wk x 12wk • Both= designed PT program		
Elshamy (2012) [15]	• n = 30 • Mean age (range) = 11.73±0.79 (10 to 13 yr) • Gender = 17 boys,13 girls • Spastic diplegic CP • Ambulant	• Exp = whole body vibration training program (WBV), 10 min. • Con = PT exercise program • 1hour, 5/wk x 6 months • Both = PT exercise program	• 6 months	• Femoral, lumbar, total body bone mineral density (BMD)=DEXA • Follow up = 0,6 months
Han (2017) [16]	• n = 18 (12 CP & 6 healthy) • Mean age (range) = 34.43±13.91 months(22 to 77 month) • Gender = 7 boys, 11 girls • GMFCS V	• Exp A = Assisted standingprogram (>2h/day x at least 5/wk) • Exp B= Standing program (20min/day x 2-3/wk) • Con(healthy) =no intervention • BothExp groups = Conventionalrehabilitation program (NDT+gross motor training+ functional electrical stimulation)	• 6 months	• Femoral bone mineral density (BMD)=DEXA • Bone length of femur and tibia= Radiograph • Follow up = 0,6 months
Khattab et al (2013) [17]	• n = 30 • Mean age (range) = 5.0±0.84 (4 to 6 yrs) • Gender = not stated • Spastic diplegic CP • DDST >10 month	• Exp= Selected exercise program wearing therapeutic suit • Con= selected therapeutic exercise program • Both= selected therapeutic exercise program (NDT+ stretching+ weight bearing exercises+ gait training) • 2hrs x 5/wk x 4 wk	• 1month	• Femoral neck & vertebral bone mineral density (BMD) =DEXA • Follow up = 0,1 months
Olama (2011) [18]	• n = 20 • Mean age (range) = 4.75± 1.25 yr(4 to 6 yrs) • Gender = 12 boys, 8 girls • Spastic	• Exp = Capacitively coupled electrical field (CCEF) and very low intensity pulsed ultrasound (LIPUS) on femoral head of paralytic side, 1 hour/day while child on	• 6 months	• Femoral neck bone mineral density (BMD)=DEXA • Follow up = 0,6 months

	hemiparetic CP • Ambulant	standing frame • Con= PT program (NDT+ faradic stimulation+ stretching+weight bearing exercises+gait training) • Both = designed PT program		
Ruck (2010) [19]	• n = 20 • Mean age (range) = 8.3 yrs (6.2 to 12.3 yrs) • Gender = 14 boys, 6 girls • GMFCS II, III, IV	• Exp=side-alternating whole body vibration (WBV) 9min/session x 5/wk during school hours • Con=unchanged individualized school PT program • 1-2/wk • Both= School PT program	• 6 months	• Distal femoral & lumbar spine (L1 to L4) areal (aBMD)=DEXA • Walking speed= 10 m walk test • Gross motor function= GMFM-88 • Follow up= 0,6 months
Wren (2010) [20]	• n = 31 • Mean age (range) = 9.4± 1.4 yrs (6 to12 yrs) • Gender = not stated • Able to stand 10 min	• Exp= Vibration period= Standing on vibrating platformat home for 10 min/day for 6 months • Con= control period= Standing on the floor without the platform foradditional 6 months.	• 6 months • 12 months	• Vertebral cancellous bone density (CBD) & tibial cross-sectional area (CSA)= CT • Calf muscle strength= Kin-Com dynamometer • Follow up = 0,6,12 months

Exp= experimental group, Con= control group, CP= cerebral palsy, CT= computed tomography, DDST= Denver Developmental Screening Test, DEXA= Dual-Energy X-ray Absorptiometry, GMFCS= Gross Motor Function Classification System, NDT= neurodevelopmental technique, PT= physical therapy.

Table 2: PEDro scores of the included studies

Study	1	2	3	4	5	6	7	8	9	10	11	Total (0-10)	Quality
Caulton et al (2004) [11]	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	**8**	**Good**
Chad et al (1999) [12]	N	Y	N	Y	N	N	N	Y	N	Y	Y	**5**	**Fair**
Chen et al (2013) [13]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	**5**	**Fair**
Eid et al (2008) [14]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6**	**Good**
Elshamy (2012) [15]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6**	**Good**
Han (2017) [16]	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	**6**	**Good**
Khattab et al (2013) [17]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6**	**Good**
Olama (2011) [18]	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	**7**	**Good**
Ruck (2010) [19]	Y	Y	Y	Y	N	N	N	N	N	Y	Y	**5**	**Fair**
Wren (2010) [20]	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	**8**	**Good**

Criteria of PEDro Scale **[8]**: 1=eligibility specified (not included in total score); 2=random allocation; 3=concealed allocation; 4=prognostic similarity at baseline; 5=subject blinding; 6=therapist blinding; 7=assessor blinding; 8=85% follow-up of at least 1 key outcome; 9= treatment and control subjects received treatment as allocated; 10=between group statistical comparison for at least 1 key outcome; and 11=point estimates and measures of variability provided for at least 1 key outcome. Scoring: N=no(absent/unclear) = 0, Y=yes (present) =1.

Table 3: Summary of results of physical therapy interventions used in the included studies

Study	Intervention	Main results	Authors' conclusion
Caulton et al (2004) [11]	• 9 months • Static standing time increased by 50% in upright or semi-prone standing frames • Compared with regular standing program	• 6% mean increase in vertebral vTBMD of the intervention group • No change in the mean proximal tibial vTBMD	• Longer period of standing improves vertebral but not proximal tibial BMD
Chad et al (1999) [12]	• 8 months • Weight bearingphysical activity program • Compared with usual lifestyle habits.	• Increase by 9.6% in femoral neck BMC, 5.6% volumetric BMD, 11.5% proximal femur BMC in the intervention group compared with: • femoral neck BMC(-5.8%) volumetric BMD (-6.3%) proximal femur BMC (3.5%) in the control group	• 8-month program of weight-bearing physical activity enhances bone mineral accrual in children with CP.
Chen et al (2013) [13]	• 3 months • Home-based virtual cycling training (hVCT) • Compared with usual physical activities (walking, running, sports or recreational school or home activities).	• hVCT group had greater distal femur aBMD and isokinetic torques of knee extensors & flexors than control group (*p*<0.05) • No difference between two groups in curl up scores, GMFM-66 and lumbar BMD	• The muscle strengthening program is more specific in enhancing bonedensity than general physical activity; 12-week hVCT is proposed for improving lower limb aBMD of children with CP
Eid (2008) [14]	• 3 months • Low intensity low frequencymagneticfield therapy added to a designed PT program • Compared with the same designed PT program alone	• Significant improvement in the post-treatment mean values of femoral neck BMD of the two groups in favor to the intervention group (p<0.05).	• Low intensity low frequencymagneticfield therapyis effective in improving femoral neck BMD of children with diplegic CP.
Elshamy (2012) [15]	• 6 months • Whole body vibration (WBV)training(25hz	• Significant improvement in the post-treatment mean values of femoral,	• WBV provides additional benefit to traditional exercise

	frequency) added to PT program • Compared with the same PT exercise program alone	lumbar & total body BMD of the two groups in favor to the intervention group ($p<0.05$).	programs, it plays an important role in improving BMD
Han (2017) [16]	• 6 monthsweight bearing exercise with standing program compared with ConventionalPTprogram	• No significant changes in femoral neck BMD in both groups • Increased trend of BMD of weight bearing group whereas decreased trend of conventional PT group • Significant increase in bone length of weight bearing group than other PT group	• Weight bearing exercise may play an important role in increasing or maintaining BMD in children with CP • It expected to promote bone growth • Programmed standing may be used as an effective treatment to increase BMD in children with CP
Khattab (2013) [17]	• 1month exercise program wearing therapeutic suit • Compared with the sameselected exercise program without the suit	• Significant improvement in the post-treatment mean values of femoral neck BMD of the intervention group • No improvement detected in the lumbar BMD of both groups	• Suit therapy can be an effective treatment modality in improving femoral neck BMD& can be used safely for children with diplegic CP
Olama (2011) [18]	• 6 monthscapacitively coupled electrical field (CCEF) and very low intensity pulsed ultrasound (LIPUS) added to adesigned PT program compared with the same PT program alone.	• Significant improvement in the post-treatment mean values of femoral neck BMD of the two groups in favor to the intervention group ($p<0.05$).	• Combined application (CCEF) & (LIPUS)is an effective therapeutic modality for improvingfemoral neckBMD of the affected side in children with hemiparetic CP.
Ruck (2010) [19]	• 6 months whole body vibration (WBV)(18 Hz frequency) added to school PT program compared with individualized school PT program alone	• Vibration therapy increased average walking by a median of 0.18 ms^{-1} (from a baseline of 0.47ms^{-1}) compared withno change in controls • No significantgroups differences in lumbar (aBMD) • Increased aBMD at distal	• WBV protocol used in this study appears to be safe in children with CP and may improve mobility function • No positive treatment effect was detected on bone.

		femoral&diaphysis in controls & decreased in WBV group (P=0.03).	
Wren (2010) [20]	• High Frequency (30 Hz), Low Magnitude Vibration compared with Standing	• Greater increases in thecortical bone properties during the vibration period (all*p*'s ≤0.03) • No difference in cancellous bone or muscle between vibration and standing(all p's > 0.10)	• The primary benefit of the vibration intervention in children with CP was tocortical bone in the appendicular skeleton.

BMD= bone mineral density, BMC= bone mineral content, CP= cerebral palsy, GMFCS= Gross Motor Function Classification System, PT= physical therapy.

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الملخص العربي

خلفية البحث:

يمكن أن تؤدي الكثافة المنخفضة للعظام لدى الأطفال المصابين بالشلل الدماغي إلى زيادة خطر حدوث الكسور و آلام العظام المزمنة، وقد يؤدي ذلك إلى تأثير كبير على جودة الحياة؛ و تم إجراء العديد من التدخلات لتحسين كثافة العظام.

هدف البحث:

تهدف هذه المراجعة المنهجيةالى دراسة تأثيرتدخلات العلاج الطبيعي على انخفاض كثافة العظام لدي الاطفال المصابين بالشلل الدماغي .

طرق البحث:

البحث في قواعد بياناتPubmed وCochrane و PEDro و مكتبة كلية العلاج الطبيعي لجامعة القاهرة و اختيار التجارب العشوائية المحكمة على الاطفال المصابين بالشلل الدماغي وانخفاض كثافة العظام المعالجة بتدخلات العلاج الطبيعي، ثم استخراج البيانات من الدراسات وتقييم جودتها المنهجية من قبل اثنين من المراجعين المستقلين باستخدام مقياس قاعدةبيانات الأدلة العلاجية (PEDro) وقد استخدم مقياس Sackett المعدل لتقييم مستوى الأدلة.

النتائج:

تم تحديد عشرتجارب عشوائية بجودة منهجية جيدة. كانت الدراسات غيرمتجانسة فيما يتعلق بخصائص العينة أو التدخلات أو النتائج، لذلك تم تحليل النتائج وصفيا. كانت هناك أدلة قوية تدعم التدخل عن طريق تحميل الوزن والاهتزاز. أدلة معتدلة للعلاج المغناطيسي والعلاج الكهربائي و البدلة العلاجية. في حين أن الأدلة محدودة حول استخدام الدراجات الافتراضية لتحسين كثافة العظام لدى الأطفال المصابين بالشلل الدماغي.

الاستنتاج:

يدعم الدليل الحالي فعالية تدخلات العلاج الطبيعي لتحسين كثافة المعادن في العظام لدى الأطفال المصابين بالشلل الدماغي.

الكلمات الدالة : الشلل الدماغي- كثافة العظام- أطفال - مراجعة منهجية.