The delivery of obesity interventions to children and adolescents with physical disabilities: a systematic review

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The Delivery of Obesity Interventions to Children and Adolescents with Physical Disabilities: A Systematic Review

Joshua T. Matizanadzo[1*], *MSc* and Priyamvada Paudyal[1], *PhD*

1. Brighton and Sussex Medical School,
Division of Medical Education, Department of Public Health and Primary Care,
Watson Building, University of Brighton, Falmer,
Brighton, East Sussex, United Kingdom
BN1 9PH

*** Corresponding Author:**
Email: joshuamatizanadzo@outlook.com
Tel: (+44) 773 9937943

Abstract

Objective: To examine the process and mechanisms of delivering obesity interventions to physically disabled children/adolescents.

Methods: PubMed, Medline, CINAHL Plus, Embase, Cochrane Library, Google Scholar, ClinicalTrials.gov, Science Direct were systematically and manually searched for studies conducted in physically disabled children/adolescents (0-18 years). Included interventions were physical activity, diet and obesity prevention education. Included outcomes were Body Mass Index (BMI)/weight and obesity prevention knowledge. The Mixed Methods Appraisal Tool aided methodological quality assessments. Data was extracted and delivery models were synthesised and narratively summarised using the Social Ecological Model.

Results: Seven studies of low (n=4) and moderate (n=3) scoring on methodological quality were eligible for inclusion. Study duration was five months or less (n=5), eight months (n=1) and two years (n=1). Interventions were delivered at home, school, hospital and rehabilitation centre through the internet, face-to-face and parents. No intervention was delivered at three or more levels of individual, interpersonal, institutional or community levels. No study reported significant outcomes on reduction in BMI/weight, or increase in obesity prevention knowledge.

Conclusion: Evidence reviewed in this study show that obesity interventions for physically disabled children/adolescents lack both in delivery and design. Gaps revealed should be considered when developing interventions for this special population.

Background and Introduction

Globally, approximately 38.2 million children aged 5 years and below were overweight or obese in 2019 (1). For those aged between 5 – 19, the rates for obesity or overweight once reached 340 million in 2016 (1). Obesity is responsible for 300, 000 deaths each year through being a gateway for non-communicable diseases which are also often associated with health inequalities and high treatment costs (2-7). Meanwhile, among those disproportionately affected by obesity are physically disabled children and adolescents (henceforth children), whose rates are approximately twice as compared to their non-disabled peers (8, 9).

The global agenda to reduce obesity in all children informs the continual redesign of schemes entrenched within children's activities at home, school and in the community. These are premised on the evidence and recommendations that physical activity and appropriate diet can reduce obesity (10). Nevertheless, despite schools prioritising 60 minutes of moderate to vigorous physical activity a day to every child, such targets are often difficult for physically disabled children to accomplish (8). Children with physical disabilities record the lowest physical activity levels compared to their peers (11) because unstructured physical activity is less ideal due to pain (12) or damaged sidewalks (13). The likelihood of poverty in families supporting a disabled child is high (14), affordability of healthy diet and payments to reach and access recreational facilities becomes a challenge. Children might have awareness of healthy diets and importance of exercise but cannot adopt these to their choices of healthy food and physical activities (15). For instance, greater levels of unhealthy food intake recorded in children with cerebral palsy has often been attributed to appetite altered by medication to relieve pain from spasticity (16).

This reveals the complexities and the context within which obesity interventions are delivered for physically disabled children. Coincidentally, this population has not been prioritised in the majority of weight management programmes and in cases when programmes do so, the design and delivery often fail to meet their unique needs (8, 17, 18). Prior evidence have focused on interventions for a population of children with heterogeneous disabilities (18), identifying approaches to reduce obesity in physically disabled children (17) and assess the effectiveness and cost-effectiveness of physical activity interventions (19). However, these reviews lack an in-depth insight into physical activity and dietary therapy interventions for physically disabled children delivered in a context characterised by multiple antecedents and complexities. This systematic review aims to describe the models of delivering obesity interventions in a population of physically disabled children particularly examining the modes, categories, levels, providers and mechanisms within physical activity and diet interventions. The review will also determine the consistency of these models identifying weaknesses and gaps that needs addressing.

Methods

This study adopted a systematic review study design, following the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines (20). Meta-analyses were not performed due to the heterogeneity of outcomes and measurements. Systematic literature searches were conducted on PubMed, Medline, CINAHL Plus, Embase and Cochrane Library, up to July 2020 using key words; "physical activity" OR "diet therapy" AND "obesity OR overweight" AND "physical disability" (Supplementary Information [SI] 2A). Citation tracking and manual searches were performed on systematic reviews, Science Direct, ClinicalTrials.gov website and Google Scholar. Studies conducted in children and adolescents (0 – 18 years) and published in English Language were eligible for inclusion.

Physical disability was defined according to the International Classification of Functionality, Disability and Health (ICFDH) as "a state of limited physical function, limited physical capacity, limited physical mobility, limited physical agility or limited physical stamina" (21). We distinguished physical disabilities from developmental disabilities because developmental disabilities encompass both physical and intellectual disabilities. Studies with children who had intellectual/developmental disabilities were excluded. Therefore, studies that mixed disabilities (physical/intellectual/developmental) and age groups (children/adolescents/youth) had to perform sub-group analysis with more than 10 participants to be included. Eligible studies had physical activity (exercises, physical training, swimming), diet (nutrition, diet therapy) and obesity prevention education (physical activity or diet education) as interventions. Outcomes eligible for inclusion were Body Mass Index (BMI)/weight, physical activity knowledge and diet knowledge either assessed as primary or secondary outcomes. Article selection was done in phases; title and abstract screening using the Rayyan Platform (22) followed by full text. Risk of bias was assessed using the Mixed Methods Appraisal Tool (MMAT) (23). The checklist was used to score the quality of articles into low, moderate and high scoring to determine the proportion of studies that fell into each category. Articles which scored <50% were considered low scoring, those scoring between 51% – 75% were considered moderate scoring while those scoring >75% were considered high scoring. The overall quality score for each study was determined by dividing the number of criteria met by the total number of criteria on the checklist (SI 2B). One author (JM) did the article selection and critical appraisal for all studies and the other author (PP) cross checked, revised and provided supervision. The methodological design constitutes delivery processes, hence, no study was excluded based on the quality of the methodological design.

Data were extracted on a number of variables that described study, population/sample, intervention and outcome characteristics (Table 1 and Supplementary Table 1). Whilst synthesising data, we positioned our findings into modes of delivery for interventional studies identified in literature (24) as well as the Social Ecological Model (SEM) (SI 2C) to elucidate mechanisms, facets and levels that influence each other (25, 26). These models provided the basis for presenting findings for this review by taking a thematic analysis approach.

Fig. 1: Flowchart for article inclusion

Results

After screening 1, 149 records, 7 studies (27-33) were eligible for inclusion in this review. Three studies were conducted in the Netherlands (28, 31, 33), two in the USA (27, 30), one in Australia (29) and one in Iran (32). Included studies were randomised controlled trials (28-31) and observational/experimental clinical trials (27, 32, 33). Based on the MMAT scoring, the proportion of studies that had a low score is 57% compared to 43% with a moderate score. Included studies were predominantly short term (below 5 months) (27-30, 32), with one medium term (6 – 11 months) (31) and one long term study (12+ months) (33). Four primary studies had physical activity in the form of exercises and physical training as interventions (28, 31-33) while three had exercise and diet education (27, 29, 30). Only two studies (27, 28) used a combination of interventions involving exercises combined with education although they did not report outcomes related to exercise education such as improvements in knowledge. Outcomes assessed were BMI (27, 28, 31), weight or fat mass (30, 32, 33) and knowledge (29). Across these outcomes, no study reported significant reductions in BMI or weight or significant improvements in knowledge. Conversely, the study by Berg-Emons and colleagues reported an increase in fat mass (33). Characteristics of included studies are summarised in Table 1 and outcomes are summarised in Supplementary Table 1. This review is focused on the delivery mechanism of the interventions and findings related to these have been summarised below under the SEM levels.

Table 1: Characteristics of Included Studies

Individual Level

At the individual level, interventions are expected to impact on the characteristics of an individual to influence behaviour change among them knowledge, attitudes and resources. Although all studies were mostly targeting the individual level behaviour, four studies (n = 4) had nutritional and physical activity education to directly improve physical activity levels and intake of healthy diets. One study used rewards and motivational tools as behaviour change techniques (27). Wingo et al., used a Health Appraisal Profile (HAP) to map out barriers, food resource levels and food choices to ensure a more individual personalised approach (30).

Delivery modes and categories

Included studies used literature and already established programmes to identify and adopt intervention components for their studies. One study structured its internet based physical activity education intervention in line with a theoretical framework, the social cognitive theory (29). Nevertheless, the study reported no significant differences between baseline knowledge scores and scores at 10 and 20 weeks assessments. Interventions were delivered over the internet through web-based videos and video chats (28-30) to influence diet and physical activity. Maher et al., used an internet based interactive exercise education programme incorporating education, quizzes, goal setting, self-reflection and positive role modelling (29). However,

exercise knowledge did not significantly differ between intervention and control groups (p = 0.20). de Groot et al., delivered treadmills to participants and blended them with a video call exercise education although this did not reach a statistically significant reduction of BMI (p = 0.1) between intervention and control group (28).

Wingo and colleagues commissioned a web-based tele-coaching intervention that combined digital health resources and personalised human interaction (30). Minor differences in weight within and between groups were reported (p values not reported). Four studies delivered their interventions in person or through face to face means (27, 31-33). However, none reported significant results across outcomes of BMI and knowledge. The only difference is that one study categorised children into two age groups, below 12 and above 13 years, although it did not report how the intervention performed in each group (31).

Interpersonal Level

The interpersonal level examine the role of social networks such as family, friends, colleagues and their impact on individual behaviours. Only two studies directly engaged parents to assist tele-coaches and physical therapist to establish nutrition and physical activity goals (27, 30). None of the studies had significant results on outcomes of interest.

Community Level

At community level, the included studies were delivered at community institutions among them school, home, rehabilitation centre and hospital. Three interventions were delivered at participants' homes where the internet and video chats were used to instruct physical activities and facilitate obesity education (28-30). de Groot et al., supplied each intervention group participant a treadmill to exercise at home supplemented by online exercise education (28). In one study, participants received education and did their practical cooking lessons at a hospital (27). Another intervention was delivered at a rehabilitation centre taking advantage of the resources for cycling and swimming (33). Although the study emulated a school-based exercise programme, it did not explicitly indicate whether this was in coordination with, and continuity of the school programme. Only one study was conducted at school (31) while the other did not report the study setting (32). Three studies reported delivering an intervention through trained personnel among them tele-coaches (30), physical therapist (27) and paediatric physiotherapist (31). Despite participants being recruited at medical or rehabilitation centres, only four studies reported how they substantiated physical disability diagnosis before the study commenced (28, 30, 31, 33).

Organisational Level

The organisational level is characterised by organisations and social institutions with rules and regulations that stipulate how services are provided to individuals and groups. Five of the included studies adopted established

guidelines, standard protocols and classification levels to guide exercises and exercise recommendations. The adopted guidelines included the Gross Motor Function Classification System (GMFCS) (29, 31), Centers for Disease Control and Prevention (30), the American Thoracic Society (28), and the MacMaster Protocol (32). One study reported using both the GMFCS and the ICFDH guidelines (31).

Timing and intensity of the delivery

Physical activity interventions varied in intensity and timing from 3 minutes to 60 minutes sessions. One study recommended a general non-prescriptive 60 minutes of physical activity (30). Liusuwan and colleagues facilitated and encouraged participants to complete an in home exercise programme 3 days a week, 10 minutes per session ultimately increasing by 5 minutes every 2 weeks, and 2 pound increments for weights from 1 to 10 and 5 pound increments for weights above 10 pounds (27). In a phased two year study, children exercised 4 times a week with each session lasting for 45 minutes (33). However, fat mass in the experimental group significantly increased over the two year period. Another similar study categorised exercises by seconds and minutes (3 – 6) with a total session lasting 45 minutes, 2 days per week for 8 months (31). One study recommended children to exercise twice a week based on adequate intensity with intervals of speeds that increased gradually and going a level up was determined when fatigue level was low (28). The duration of each exercise session was not reported. Izadi et al., reported 3 exercise sessions a week lasting 20 – 25 mins, with heart rates and fatigue closely monitored over 3 months period (32). An Australian study had a weekly web-based education for 8 weeks although the duration of the each weekly lesson was not reported (29). None of the studies reported adverse events. Nevertheless, like all the aforementioned levels, varying intensity, timing and techniques did not contribute significantly to reducing BMI, weight or improvements in diet or exercise knowledge.

Discussion

Main findings of this study

This systematic review summarised the findings of seven primary studies with the objective of probing the delivery of obesity management interventions to physically disabled children. The studies were heterogeneous in design, outcome measurements, interventions and delivery methods. The reviewed studies were conducted at home, school, hospital and rehabilitation centre through parents and trained personnel, with interventions that varied in intensity. Establishing goals using HAP (30), giving each participant a treadmill (28) and using technology (29) are outstanding intervention delivery techniques reported in this review. Despite these techniques, none of the included studies reported significant results on reducing BMI and weight or improving obesity prevention knowledge. Lack of nutrition interventions to practically transform food choices outside of basic diet education is concerning. Prior evidence suggests that combined diet and physical activity interventions can reduce the risk of obesity in children (34). Therefore, this might render reviewed

interventions as incomplete enough to make an effect by not pairing physical activity and dietary interventions as the relationship between these two factors are important in obesity.

The SEM adopted by this study might give suggestions on how the delivery aspects might have influenced insignificant outcomes. At interpersonal level, physically disabled children can engage with the intervention with disabled and non-disabled peers and networks. Similarly, coordination of interventions between organisations and institutions (religious, business, healthcare), community settings (built environment) and policy lacked. Although these aspects are not prescriptive, they might offer the recommended multi-component, multi-setting and multi-level delivery strategies (35-38) by systematically connecting all levels while attempting to customise the affordability of healthy diets and surrounding environment for safe unstructured physical activity.

The findings of this review expose the complexities of reducing obesity in physically disabled children and echo the inconsistencies in the design of intervention components and delivery mechanisms. Therefore, it becomes evident from this point of view that there exists a paucity of studies to make recommendations on which delivery process is appropriate for preventing obesity in physically disabled children. These gaps can only be addressed through optimally designed and consistent research.

What is already known on this topic

Our scan for prior evidence (10, 34, 39) gave an indication that physically disabled children have often been left out but it is not clear whether this is systematic, deliberate or coincidental. Previous reviews (17-19) identified limited effectiveness of physical activity and diet in reducing obesity in physically disabled children. One review (17) reported positive outcomes from allowing a child to self-direct activities, motivational strategies and incremental increases in workloads while the other (18) reported the use of technology as promising. Both reviews reported positive outcomes when parents are engaged. The other review reported the potential of physical activity interventions to improve health, well-being and fitness of wheelchair users (19). Nevertheless, the consistency of the delivery process to the needs and capabilities of physically disabled children specifically looking at the effect of interacting multilevel influences was not fully assessed in these reviews.

What this study adds

To the best of our knowledge, this is the first systematic review to examine the processes of delivering obesity management interventions to physically disabled children, with the objective of identifying what works, for whom, how and in what circumstances. By adopting the SEM, this study unearthed how primary evidence lack both in delivery and design as the studies failed to account for components that are interrelated in causing obesity. By doing so, the review has unpacked the complex contexts within which obesity interventions are

delivered which might not only require one component intervention but multicomponent interventions as well as addressing some antecedents connected to obesity. This provides a basis to understand delivery processes and mechanisms so that obesity interventions can be fully embedded in every practices at home, school and in the community as well as spur on further research.

Limitations of the included studies

An important consideration is the methodological limitations within the included primary studies. Common limitations include small (27-30, 32, 33) and medium (31) sample sizes, lack of a clear sampling strategy (27, 28, 30, 31, 33) and recruiting volunteers (32). This affect the representation of the sample and the generalisation of the study results. Three studies did not report how they confirmed physical disability status, such as through medical records or other means (27, 29, 32). This might be important to identify components that might be appealing to a participant. Other limitations are attrition rates reaching 38% (30), not randomising participants (27, 32), not blinding assessors (28, 30, 33) and not accounting for the effects of confounding (27, 29, 31-33).

Limitations of this study

We did not perform meta-analyses due to the heterogeneity of outcomes and measurements. This review focused more on delivery mechanisms than intervention effectiveness, hence the narrative synthesis was a more appropriate methodology. Inclusion of physical disability and age proved to be a challenge. Furthermore, this study did not search all the databases and did not include studies published in another language other than English. However, this systematic review becomes necessary for policy makers, health promoters and researchers. The implementation of evidence from studies to a larger population has often been cited as difficult (40, 41), this study gives an indication of what, why and how some programmes fail.

Conclusion

This review examined evidence from seven primary studies on interventions for physically disabled children and adolescents delivered at home, school and rehabilitation centre using technology and in person modes. However, there is paucity of research on the delivery of obesity in this population and the included studies are characterised by non-significant results across a range of outcomes and poor methodological designs. There is need for interventions structured along a sound methodology to be conducted in this population, optimally designed to account for multilevel, multicomponent and multi-setting effects. Overall, this paper demonstrated that effectiveness of obesity interventions in physically disabled children cannot only be based on how the intervention produced significant results but on how appropriate were the delivery processes. In doing so, it revealed the gaps and weaknesses that should be considered when developing and locating components of interventions for this special population.

Keywords

Obesity, Physical activity, Diet, Nutrition Education, Children, Adolescents, Physical Disability, Body Mass Index, Systematic Review, Intervention delivery

Additional Information

1. Supplementary Table 1: Outcomes of Included Studies

2. Supplementary Information 2A-D: Search Strategy, Critical Appraisal Outputs, Social Ecological Model and Characteristics of Excluded Studies.

Abbreviations

BMI – Body Mass Index

GMFCS – Gross Motor Function Classification System

HAP – Health Appraisal Profile

ICFDH - International Classification of Functioning, Disability and Health

MMAT – Mixed Methods Appraisal Tool

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-analysis

SEM – Social Ecological Model

USA – United States of America

Conflict of Interest

All authors declare no conflict of interest.

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Author Contribution

JM: Conceptualised and designed the study, searched for articles, quality assessment and data extraction, writing original draft, revisions and final approval of submitted draft.

PP: Supervision, revisions, and final approval of submitted draft.

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Table 1: Characteristics of Included Studies

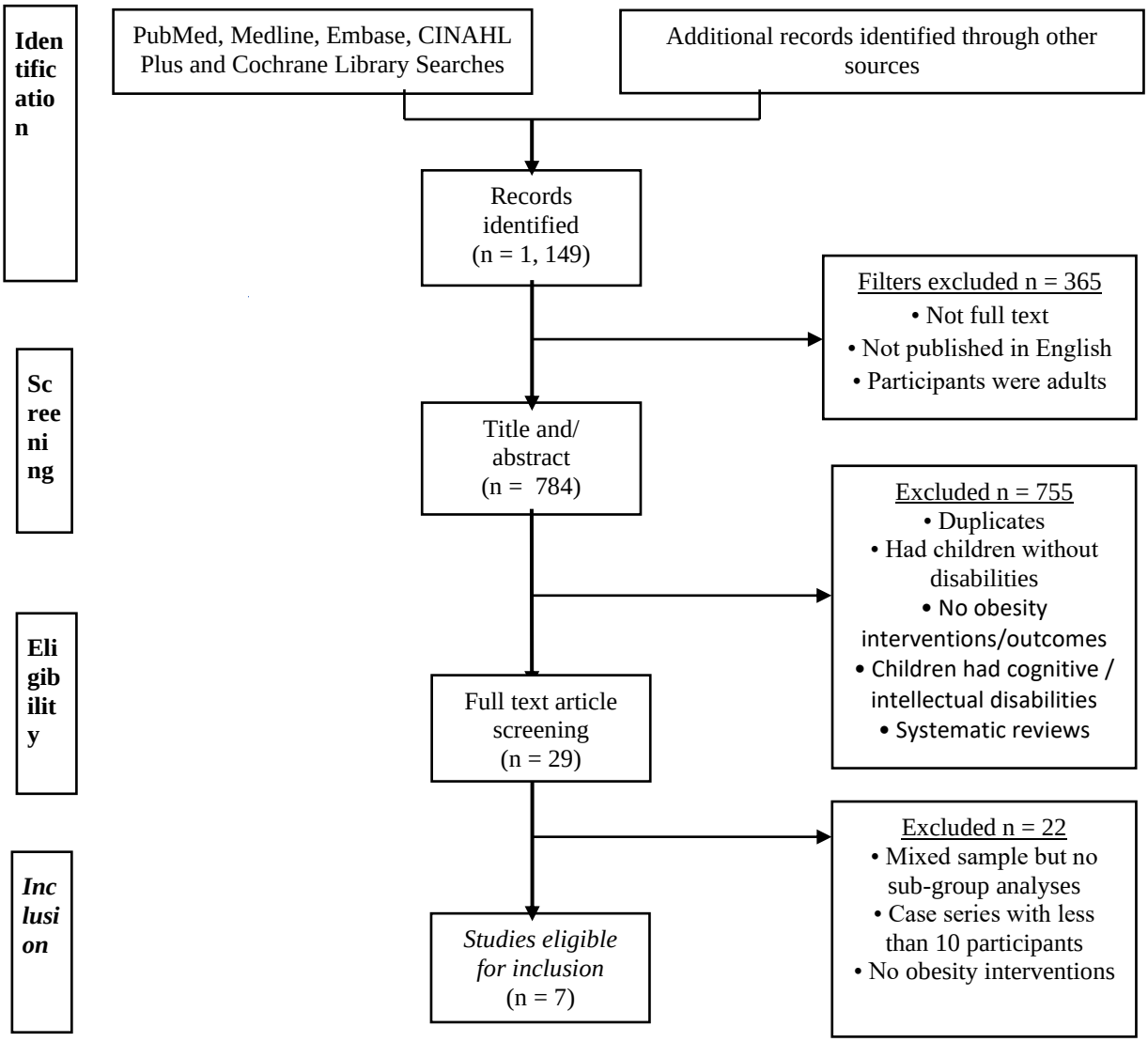
Author & Year	Country	Study Aim(s)	Study design	Sampling (random / convenient)	Total sample & Gender	Mean age (age range years)	Physical Disability & % with comorbidities	Intervention details & Length
(27) Liusuwan et al, (2007)	USA	• Determine the effects of a nutrition education and exercise intervention on the health and fitness of adolescents with mobility impairment due to spinal cord dysfunction from myelomeningocele and spinal cord injury.	Observational (2 staged pilot study)	None reported	• n = 20 • 12 girls • 8 boys	• Mean age 15.4 (SD 2.2) • (11 - 18)	• Mobility impairments due to spinal cord dysfunction. • 4 were fully ambulatory but with impaired gait, 16 used wheelchairs • No comorbidities reported	• Nutrition education • Exercise education • Exercises • 16 weeks
(28) de Groot et al, (2011)	Netherlands	• To evaluate the effects of a home-based treadmill training program on both ambulatory function and aerobic fitness.	Randomised clinical trial	None reported	• n = 32 • 18 boys • 14 girls	• mean age 10.7 (SD 2.8) • Not reported	• all 32 children with Spina Bifida (SB) were ambulatory • No comorbidities reported	• Treadmill exercise • Exercise education • 12 weeks
(29) Maher et al, (2010)	Australia	• To determine the effectiveness of an 8-week internet-based, lifestyle physical-activity intervention for adolescents with cerebral palsy (CP) • Secondly, to determine the effectiveness of the intervention in improving exercise knowledge, attitudes, self-efficacy and intentions, increasing functional capacity, and decreasing sedentary behaviours.	Randomised controlled trial	None reported	• n = 41 • 26 males • 15 females	• Mean age 13.7 (SD 1.8) • (11 – 17)	• Mild to moderate cerebral palsy (CP), with ability to ambulate with or without mobility aids • Unilateral CP (n = 16) • Bilateral CP (n = 25) • No comorbidities reported	• Physical activity education • Combined with usual care. • 8 weeks
(30) Wingo et al, (2020)	USA	• To examine the usability and preliminary efficacy of an e-health and tele-coaching intervention compared to tele-coaching alone. • Secondary: Explore changes in health behaviours between those who receive the telehealth intervention and those who received only telephone support	Randomised pilot study	None reported	• n = 50 • 21 males • 29 females	• Mean age 11.3 (SD ± 3.3) • (6 - 17)	• Spina bifida (25), Cerebral Palsy (7), Stroke (1), Others (17) • 82% used some type of assistive of mobility aid • Children with comorbidities were excluded	• Physical activity education • Healthy diet education • 12 weeks
(31) Verschuren et al, (2007)	Netherlands	• To evaluate the effects of an 8-month training program with standardized exercises on aerobic and anaerobic capacity in children and adolescents with cerebral palsy.	Randomised controlled clinical trial	None reported	• n = 86 • 44 males • 24 females	• Mean age 12.1 (SD 2.6) • (7 – 18)	• Cerebral palsy • Were receiving rehabilitation at the time the study was conducted • No comorbidities reported	• Exercises • 8 months

(32) Izadi et al, (2006)	Iran	• To assess the effect of sub-maximal rehabilitation program (aerobic exercise) on maximal oxygen uptake, oxygen pulse and cardio-respiratory physiological variables of children with moderate to severe spastic cerebral palsy diplegia and compare with able-bodied children.	Controlled clinical trial	Voluntarily selected	• n = 33 • Gender not reported	• Mean age 12 (SD 2) • (not reported)	• Cerebral palsy	• Exercises • 3 months
(33) Berg-Emons et al, (1999)	Netherlands	• To assess whether two 9 months aerobic and sports programmes can increase the level of daily physical activity and have favourable effects on fat mass in school children with spastic cerebral palsy	Experimental controlled trial	None reported	• n = 20 • 11 boys • 9 girls	• Mean age 9.2 (SD 1.4 kg) • (7 – 13)	• Spastic cerebral palsy • The physician classified the sample into diplegic (n = 16) or tetraplegic (n = 4) • Half of the children were ambulant and the other half was wheel chair bound	• Physical training • 2 years

*Abbreviations: CP – Cerebral Palsy, SB – Spina Bifida, USA – United States of America

Table 1 above summarise the Characteristics of Included studies. The Outcomes of these studies are summarised in Supplementary Table 1.

. 1: Flowchart for article inclusion



PRISMA diagram adapted from Moher et al, (2015)[22]

Supplementary Information 2

2A: Search Strategy

Database: Ovid MEDLINE(R) Search Strategy:

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1 exp *Obesity/dh, dt, pc [Diet Therapy, Drug Therapy, Prevention & Control] (20044)
2 exp Overweight/dh, pc, rh, th [Diet Therapy, Prevention & Control, Rehabilitation, Therapy] (43413)
3 exp Disabled Children/ (6034)
4 exp Multiple Sclerosis/ or exp Disabled Persons/ (119286)
5 exp Cerebral Palsy/ (19904)
6 "reduced limb function".mp. (1)
7 Spinal Cord Injuries/ or "Recovery of Function"/ or Muscle Spasticity/ (90698)
8 Spinal Dysraphism/ (5972)
9 Meningomyelocele/ (4001)
10 exp Mobility Limitation/ (4319)
11 impairment.tw. (273689)
12 dystrophy.tw. (41710)
13 "reduced limb function".tw. (1)
14 exp Developmental Disabilities/ (19487)
15 "special care needs".tw. (86)
16 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 (555073)
17 "school health services".tw. (502)
18 community based services.tw. (1238)
19 exp "Delivery of Health Care"/mt [Methods] (21060)
20 exp Diet/ or Diet Therapy/ (278511)
21 weight management.tw. (5754)
22 weight reduction.tw. (8830)
23 exp Exercise Therapy/ (47935)
24 exp "Physical Education and Training"/ (13300)
25 physical activity.tw. (100442)
26 exp Swimming/ (23895)
27 exp Health Promotion/ (74196)
28 exp Health Education/ (237292)
29 exp Obesity Management/mt [Methods] (8581)
30 obesity interventions.tw. (503)
31 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 (695552)
32 1 or 2 (49291)
33 16 and 31 and 32 (292)

2B: Critical Appraisal of Included Studies

Study citation	Is randomization appropriately performed? No = 0, Yes = 1	Is the sampling strategy relevant to address the research question?	Is the sample representative of the target population?	Are the groups comparable at baseline?	During the study period, is the intervention administered as intended?	Did the participants adhere to the assigned intervention?	Are outcome assessors blinded to the intervention provided?	Are there complete outcome data?	Is the risk of nonresponse bias low?	Are the confounders accounted for in the design and analysis?	Are measurements appropriate regarding both the outcome and intervention?	Scoring	Scoring interpretation – lower scoring, moderate scoring, higher scoring
Liusuwan et al., (2007)	0	0	0	1	0	1	0	1	1	0	1	5	Low scoring
de Groot et al., (2011)	1	0	0	1	1	1	0	1	1	0	1	7	Moderate scoring
Maher et al., (2010)	1	0	0	1	1	1	0	1	1	0	1	7	Moderate scoring
Wingo et al., (2020)	1	0	0	1	1	1	0	0	0	0	1	5	Low scoring
Verschuren et al., (2007)	1	0	0	1	1	1	1	1	1	0	1	8	Moderate scoring
Izadi et al., (2006)	0	0	0	0	1	1	0	1	1	0	1	5	Low scoring
Berg-Emons et al., (1999)	1	0	0	1	1	0	0	0	1	0	1	5	Low scoring

Supplementary Information 1: Outcomes of Included Studies

Author & Year	Delivery setting	N completed post intervention assessment	Time points measured	Post intervention follow up	Delivery of intervention. Length	Results or outcomes
(27) Liusuwan et al, (2007)	Hospital	14 of the total 20	Pre and post intervention	None reported	• 9 biweekly sessions covering 16 weeks with alternating topics of exercise education and nutrition concepts. Modifications were held between parents, participants and a physical therapist • Lessons on: (1) categorising foods into free, light and junk, (2) importance of physical activity, (3) awareness of nutritional intake while dining out and (4) appropriate portion control by using visuals. • Practical lessons involved portion control of pasta and meat and calculating the amount of fat and calories in own made pizza. Participants recorded daily food intake and completed nutrition assignments each week. • Participants completed an in home exercise programme 3 days a week 10 mins per session ultimately increasing by 5 minutes every 2 weeks, 2 pound increments for weight from 1 to 10 and 5 pound increments for weights above 10 pounds. Participants recorded their daily exercise activities, number of minutes performed and repetitions made • Games, rewards and motivational tools were used to promote active participation.	• 0.0 non-significant mean BMI change from 64.2 kgs (+/- 4.99kgs) pre-intervention to 64.4 (+/- 5.2 kg) post intervention. • – 2.1 non-significant reduction in body fat, from mean 27.4 kgs pre intervention to 26.7 kgs post intervention.
(28) de Groot et al, (2011)	Home	32 of the total 32	Pre, post and 3 months post-intervention follow up	• 3 months after the intervention had concluded	• Intervention Group (n = 18): Treadmills were offered to the participants for use at their homes • Participants were encouraged individualised and supervised treadmill training twice a week based on adequate intensity • Intervals of speeds increased gradually and going a level up was determined when fatigue level is low • Control group (n = 14): Children in this group were instructed to maintain regular care and regular patterns of physical activity	• No significant differences on BMI = mean -0.3, (SD 0.9) for control and mean -0.1 (SD 0.9) for intervention, p = 0.1 • No significant difference on weight, mean 1.0 (SD 1.9) for control and 0.2 (SD 1.6) for intervention, p = 0.2 • No significant differences in follow up assessments
(29) Maher et al,	Home	41 of the total 41	• Baseline, 10 weeks (post	• At 20 weeks since the	Intervention (12 males, 8 females): Participants completed the 8 week Get Set programme, 10 and 20 week follow up assessments were conducted	• Exercise knowledge: No significant difference between

(2010)			intervention) and 20 weeks	intervention had started	• 8 module, interactive internet based programme based on social cognitive theory + usual care. • Modules released weekly on the website incorporating education, quizzes, goal setting, self-reflection and positive role modelling. • One on one introduction or training before starting the program and weekly email or mobile phone text messages encouraging them to login weekly for the 8 week duration • Control group (14 males, 7 females), were encouraged to continue with their usual activities and received no contact from the investigators throughout the intervention period	baseline scores and 10 week and 20 week assessment • Intervention: baseline 5.0 (2.1), 10 weeks = 6.2 (1.9), 20 week = 5.7 (1.8) p = 0.60. mean change 1.2 (2.4), f value = 3.2, p = 0.08, mean change at 20 week 0.7 (2.1), p = 0.20 • Control: baseline = 5.3(1.9), 10 weeks = 5.4(2.2), 20 week = 5.7(2.8) mean change at 10 weeks of 0.1(1.7), mean change of 0.4(2.3) at 20 weeks • Post intervention BMI not reported
(30) Wingo et al, (2020)	Home	40 out of the 50 who had completed baseline, out of the 65 who had initially been randomised	• Pre and post intervention	None reported	• Physicians verified exercise and diet restrictions for each participant • Each participant completed a Health Appraisal Profile (HAP) at baseline on health conditions, disability, access to resources for healthy food and exercise, distinctive food preparation functions in the home, readiness for change and barriers to change. • E-health and Telephone Group (9 males, 15 females). This group accessed a web-based tele-coaching to influence diet and physical activity behaviour by combining digital health resources and human interaction personalized approach for 12 weeks • The participant's HAP responses and parents enabled the establishment/identification of diet goals and physical activity changes. • Tele-coaches negotiated and refined these goals with parents, offered behavioural recommendations and resources to meet each goal basing on established dietary Guidelines. Parents choose what is achievable if they felt their child was not ready for a challenging goal. • Non-prescriptive physical activity recommendations were set at 60 mins per day, starting with goals even lower than 60 based on the decision between parent and tele-coach. • Parents recorded child's daily food intake and physical activity patterns on the online platform and received feedback and instructions during tele-coaching sessions on what food	• Minor differences in weight within and between groups Weight (kg; mean, SD)(p values not reported) • Intervention 53.22 (30.51) at baseline, 56.26 (34.05) after intervention • Control group 50.47 (27.29) at baseline, 52.54 (26.86) post intervention

					to be served more or less • Participants received weekly phone calls from the tele-coach consecutively in the first 6 weeks, and every other week during the second 6 weeks • Telephone Only (TO) Group (12 males 14 females). Participants in this group received telephone calls from the tele-coach but did not have access to the online platform and had no individual goals and recommendations in their package. • The tele-coach provided the TO group with information on how to access nutrition and physical activity guidelines and resources on another website and hands on demonstration on how to use these resources	
(31) Verschuren et al, (2007)	School	65 completed, of the 68 randomised and 86 assessed for eligibility	Baseline, 4 months, 8 months and 12 months since baseline	12 months since baseline	• Children were receiving rehabilitation and disability was tracked from the medical progress records. • Training group (20 males and 14 females): Exercise sessions led by paediatric physiotherapists during school hours at school, lasting 45 minutes , 2 days per week for 8 months. + Usual care • 8 standardised aerobic exercises that lasted 3 to 6 mins and 8 standardised anaerobic exercises lasting 20 to 30 seconds • Task specific exercises such as running step ups and negotiating stairs were done randomly throughout the programme, each training • Small group exercises categorised into two by age group 7- 12, 13 – 18 consisting of 4 to 6 participants • Control group (24 males and 10 females): Received usual care or rehabilitation.	• No significant difference in BMI • Training group mean BMI reduction 0.7 (SD2.1) compared to 0.3 (SD1.1) in the control, p = 0.51
(32) Izadi et al, (2006)	Not reported	13 of the 15 in the experimental group completed post-test assessment	• Baseline and post – test at 3 months	• None reported	• 15 voluntarily selected children with spastic diplegia cerebral palsy (experimental group) and 18 normal children in control group • sub-maximal exercise rehabilitation program was performed with an average of exercise intensity (144 beat per minute of heart rate), 3 sessions per week (each session of exercise lasted 20-25 minutes) for 3 months and all variables were calculated. • If fatigue was noticed in the participants, or those with heart rates approaching to 170 (beat/min), the test would be stopped at that stage	• Mean weight in experimental group 29.83 kgs (±5.64) pre-test, and post-test 30 kgs (±5.80) (p values not reported). • Control group reported mean weight was 28.14 kgs (±4.18)
(33) Berg-Emons et al, (1998)	Rehabilitation centre	18 completed post-test assessments	Baseline, 2 months, 4 months, 9 months and	• None reported	• Physician categorised spastic CP into two groups • 2 years length with two training periods of 9 month each, gapped by a school holiday. • Experimental group (4 males, 6 females): 45 min exercise sessions four times a week and the school training programme which had two time 45 minute sessions per week	• Experimental group FM showed no changes, mean 8 kg at baseline, mean 8kgs at 9 months and 8.6kgs at 12 months.

			12 months		• Cycling, wheelchair driving, running, swimming, training on a flying saucer and mat exercises • Habitual diets of the children were not changed during the programme • Control (7 males, 3 females): two 45 minutes gymnastic lessons per week (school programme)	• Control group FM significantly increased, baseline of 5.7kgs to 6.8kgs at 9 months ($p < 0.05$) to 7.2kgs at 12 months, $p < 0.01$ • Second 9 months phase, Experimental group FM increased by +0.7 (SD 0.7 kg, $p < 0.05$) compared to first 9 months phase. • Experimental group FM in the second phase increased significantly different ($p < 0.05$) between children who had trained during the first year ($n = 8$) (+ 0.9 SD 0.9 kg) and children who had not trained during the first year ($n = 9$) - 0.3 SD 0.9) • FM for children who had exercises 4 times a week only significantly increased baseline of the second year as compared to the previous years' baseline ($p <0.01$)

Abbreviations: BMI – Body Mass Index, CP – Cerebral Palsy, FM – fat mass, HAP – Health Appraisal Profile,