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Review Article

Exercise therapy for children with obesity: a systematic literature review

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Abstract

Background: Obesity in childhood increased in recent years steadily and affects 14 million children in Europe. Since this disease presents a serious health risk and can develop into complications in adulthood, measures must be taken to prevent further damage.

Methods: A systematic literature review was carried out in PubMed, MedPilot, CINAHL, Embase, and the Cochrane Library. Randomized controlled trials were included if they were published in the years 2006-2016, were written in German or English and described interventions with children from 0-18. Further studies were included manually. All studies were evaluated by the PEDro-scale and the impact of the intervention was compared by the body mass index (BMI) value.

Results: Five studies out of the first found 986 were included with a total of 605 children with obesity, thereof 328 in intervention groups and 277 in control groups. Children of the intervention groups undertook on average 100 minutes of exercise per week over three to 24 months periods. A reduction of the BMI value was proven only in four studies and varied from -0.1 kg/m^2 up to -0.46 kg/m^2 with different interventions.

Conclusions: Adequate physical therapy including resistance and endurance training can help improve BMI in children with overweight and obesity.

Keywords: children, eating disorders, exercise therapy, obesity, weight loss

Introduction

Obesity is one of the world's biggest health problems in the 21st century and has developed into a core problem, according to the World Health Organization (WHO) [1]. For a total population of 742 million people in Europe [2], including 114 million children [3], there are 14 million children with overweight and three million children with obesity [4]. In the years 2003-2006, the Robert Koch Institute (RKI) carried out a representative child and adolescent health survey with more than 17,000 children and adolescents aged 0-17 years and showed that the number of children and adolescents with overweight or obesity increased significantly in the last 25 years.

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The study identified approximately 1.9 million children and adolescents with overweight, of whom approximately 800,000 were children with obesity [4]. According to the WHO, an increased body-measure index (BMI) is one of the top ten risk factors for mortality and morbidity worldwide [5-7].

The causes of obesity are multifactorial, likewise the risk factors of overweight and obesity [4]. The various consequences and accompanying diseases of obesity can manifest themselves in childhood. These include, for example, metabolic, cardiovascular, pulmonary, and psychosocial diseases as well as developmental disorders [8]. Furthermore, the early onset of puberty and menarche, musculoskeletal and hepatobiliary diseases are described because of obesity [9]. Possible complications are orthopedic disorders such as disturbances of the supporting and holding apparatus, genu valgus, fallen arches, joint pain, or spinal deformity [10].

Objectives

Within the framework of this study, the problematic of children with obesity is analyzed by a systematic literature review, as well as the effectiveness of exercise therapy regarded to weight reduction for the improvement of the health condition is evaluated. This leads to the following research questions:

1. Which exercise therapy approach for children and adolescents with obesity is described as effective in relation to weight reduction in the literature?
2. Are there guidelines for the treatment of childhood obesity?
3. Which recommendations for weight reduction for children and adolescents with obesity can be found in the literature?
4. How should a training program be designed so that the weight reduction can be achieved?

Table 1. Based on BMI measurements of children's and youth health surveys [4]

	Strong below normal weight (<P3) % (95% CI)	Below normal weight (P3->P10) % (95% CI)	Normal weight % (95% CI)	Overweight, not obese (>P90-P97) % (95% CI)	Obese (>P97) % (95% CI)	Subjects (n)	No measured value %
3-6 years							
Boys	1.3 (0.9-2.0)	4.0 (3.2-5.0)	85.8 (83.8-87.5)	6.4 (5.2-7.9)	2.5 (1.8-3.4)	1934	0.8
Girls	1.5 (1.0-2.3)	3.6 (2.8-4.8)	85.5 (83.7-87.1)	6.0 (5.1-7.1)	3.3 (2.4-4.5)	1902	1.2
Total	1.4 (1.1-1.9)	3.8 (3.2-4.6)	85.6 (84.4-86.8)	6.2 (5.4-7.1)	2.9 (2.9-3.6)	3836	1.0
7-10 years							
Boys	2.0 (1.5-2.9)	5.1 (4.1-6.3)	77.0 (74.9-79.0)	8.9 (7.6-10.4)	7.0 (5.8-8.3)	2119	0.3
Girls	1.8 (1.2-2.7)	6.7 (5.4-8.2)	76.8 (74.3-79.1)	9.0 (7.6-10.7)	5.7 (4.7-6.9)	2012	0.5
Total	1.9 (1.5-2.5)	5.9 (5.1-6.8)	76.9 (75.3-78.4)	9.0 (8.0-10.0)	6.4 (5.6-7.3)	4131	0.4
11-13 years							
Boys	2.5 (1.8-3.6)	7.0 (5.7-8.5)	72.2 (69.6-74.6)	11.3 (9.7-13.1)	7.0 (5.6-8.7)	1897	0.3
Girls	2.3 (1.5-3.5)	5.5 (4.3-6.9)	73.3 (70.5-75.9)	11.6 (9.8-13.7)	7.3 (5.9-9.0)	1819	0.8
Total	2.4 (1.8-3.2)	6.2 (5.3-7.3)	72.7 (70.6-74.7)	11.4 (10.1-12.9)	7.2 (6.1-8.3)	3716	0.6
14-17 years							
Boys	2.4 (1.7-3.3)	4.8 (3.9-5.9)	75.6 (73.4-77.7)	9.0 (7.8-10.4)	8.2 (7.0-9.5)	1897	0.3
Girls	1.4 (0.9-2.3)	4.9 (3.9-6.0)	76.8 (74.5-78.9)	8.1 (6.7-9.7)	8.9 (7.5-10.4)	1819	0.8
Total	1.9 (1.4-2.5)	4.8 (4.2-5.6)	76.2 (74.6-77.7)	8.6 (7.7-9.6)	8.5 (7.6-9.6)	3716	0.6
3-17 years							
Boys	2.1 (1.7-2.5)	5.1 (4.6-5.7)	77.7 (76.5-78.9)	8.8 (8.0-9.7)	6.3 (5.6-7.0)	7530	0.5
Girls	1.7 (1.4-2.1)	5.1 (4.5-5.8)	78.2 (77.0-79.3)	8.5 (7.9-9.2)	6.4 (5.8-7.1)	7217	0.7
Total	1.9 (1.6-2.2)	5.1 (4.7-5.6)	78.0 (77.0-78.9)	8.7 (8.2-9.2)	6.3 (5.8-6.9)	14.747	0.6

Background

With a prevalence of approximately 1.9 million children and adolescents with overweight in Germany, of which approximately 800,000 are children with obesity, this is a relevant therapeutic issue. Exemplary the BMI values of 14,747 children and adolescents aged 3-17 years are shown in Table 1 [4].

As already described by Kurth and Schaffrath Rosario in 2007, the proportion of persons with overweight increased to 9% among 3-6-year-olds, to 15% to 7-10-year-olds and to 17% to 14-17-year-olds. The proportion of children with obesity rose to 2.9% among 3-6-year-olds, to 6.4% with 7-10-year-olds and to 8.5% with 14-17-year-olds [4].

Based on these results, it can be compared with the reference data from the 1980s and 1990s, that a rise of 50% for children and adolescents with overweight and obesity has taken place.

Methods

This systematic literature review was carried out in the medical databases PubMed, MedPilot, CINAHL, Embase, and the Cochrane Library with the following search syntax (Table 2).

Table 2. Search syntax of the systematic literature review

Exercise therapy	AND	Obese children	AND	Weight loss
Obese children	AND	Exercise therapy	NOT	Eating disorder
Physical activity	AND	Obesity	AND	Weight loss

The identified literature had to meet the following inclusion criteria:

- Studies which corresponded to the basic subject of this study
- Published in the last ten years
- Studies written exclusively in English or German
- Studies on children aged 0-18 years
- Only randomized controlled trials (RCT)

The qualitative evaluation of the included studies was based on the PEDro scale (Physiotherapy Evidence Database). The Pedro scale counts as a reliable and valid instrument to measure the quality of RCT's which are composed of eleven criteria [11].

Results

The flow chart (Figure 1) shows the initial number of n = 986 studies, which resulted from the search in the databases and other sources. After considering the inclusion and exclusion criteria, 612 studies could be excluded. The titles of the remaining 356 studies were examined to see whether they fit into this study. Further 302 studies were excluded because of duplications and wrong topics. In 54 studies a review of the abstracts followed, of which 31 were not compatible with the topic of this work.

A total of 23 full texts were assessed as being suitable, in which 21 studies did not meet the inclusion criteria. From the literature research of the databases, two studies could be included, and three studies were added after hand search.

Critical appraisal of included studies

In the following, the critical appraisal of the study quality is presented by using the PEDro scale (Table 3). The PEDro score ranges from five to six points (median=6).

At the beginning of all five studies, the groups were initially comparable related to the most important prognostic indicators. Volunteers and therapists were not blinded in all studies; the same applies to those who have measured the central outcome. The included five studies were all RCTs and the studies of which Maddison et al [12] and Savoye et al [13] were performed blinded. In the studies of Maddison et al and Savoye et al less than 85% of the original volunteers could be used at the end of the intervention [12,13]. The other criteria were answered with "yes", except for one study which did not report on point and scatter measures as a central outcome [14]. All included RCTs, which were carried out from 2006 to 2015, are presented individually.

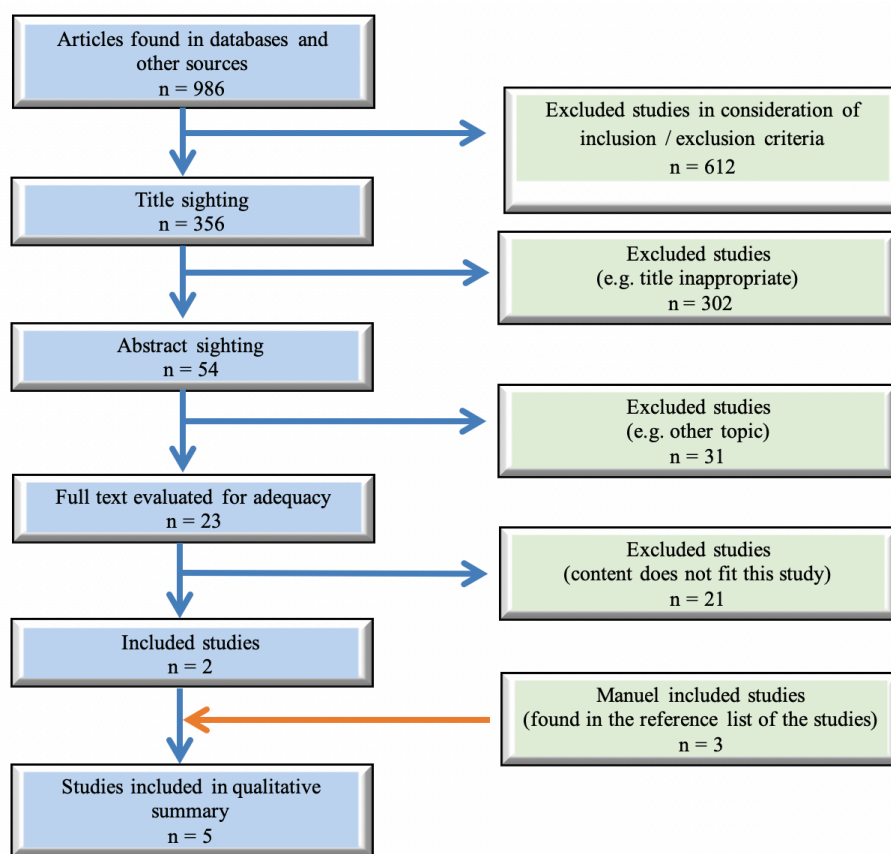


Figure 1. Flow chart of the study procedure

Table 3. Study evaluation according to the PEDro scale [22]

Studies	Pedro-Criteria											Total
	(1)	2	3	4	5	6	7	8	9	10	11	
Farpour-Lampert et al, 2009	+	+	-	+	-	-	-	+	+	+	+	6/10
Lee et al, 2013	+	+	-	+	-	-	-	+	+	+	+	6/10
Maddison et al, 2011	+	+	+	+	-	-	-	-	+	+	+	6/10
Weintraub et al, 2008	+	+	-	+	-	-	-	+	+	+	-	5/10
Savoye et al, 2011	+	+	+	+	-	-	-	-	+	+	+	6/10

The study by Farpour-Lampert et al [15] is presented in Table 4. It occurred over three months with a total of 44 volunteers and examined a possible reduction of the BMI with a 60-minute intervention.

The intervention was performed by two experienced physiotherapists; the heart rate during the aerobic exercise should correspond to 55-65% of the individual maximum cardiorespiratory fitness. The authors show increased cardiorespiratory fitness and could detect a reduction in the BMI of 0.1 kg/m² but no statistically significant results.

Table 4. Study characteristics [15]

Title	Physical activity reduces systematic blood pressure and improves early markers of atherosclerosis in pre-pubertal obese children
Author/ Year	Farpour-Lampert et al, 2009
Length of study	Three months
Number and age of participants	44 pre-pubertal children with obesity (8.9 ± 1.5 years) (intervention group and control group each n = 22)
Measured values	BMI
Intervention	60 minutes 3 x per week: 30 minutes aerobic exercises, 20 minutes strengthening exercises, 10 minutes stretching / cool down
Results	Baseline: n = 22 BMI (kg/m^2) 25.4 After three months: n = 22 BMI (kg/m^2) 25.3
Design	RCT
Assessment	PEDro-Scale: 6/10

The study by Lee et al [16] took place over three months with a total of 44 volunteers, which were divided into three groups. A control group with 12 volunteers, two intervention groups with 16 volunteers, one of whom did the aerobic exercises (AE) and one of the resistance exercises (RE) as an intervention. Both groups trained three times a week, each 60 minutes, under the supervision of graduate students. The results of the AE group show a reduction of the BMI by $0.46 \text{ kg}/\text{m}^2$, the RE group a reduction of the BMI by $0.28 \text{ kg}/\text{m}^2$. Compared with controls body weight did not change in both groups ($p > 0.1$). The authors explain, that in obese adolescent girls, AE but not RE is effective in reducing liver fat and visceral adiposity (Table 5).

Table 5. Study characteristics [16]

Title	Aerobic exercise but not resistance reduces intrahepatic lipid content and visceral fat and improves insulin sensitivity in obese adolescent girls: a randomized controlled trial
Author/ Year	Lee et al, 2013
Length of study	Three months
Number and age of participants	44 girls with overweight (≥ 95 . percentile) (12-18 years) (intervention group aerobic exercises n = 16, intervention group resistance exercises n = 16, control group n = 12)
Measured values	BMI, body fat, muscle mass, fitness, insulin
Intervention	AE: 60 minutes 3x per week Five minutes warm up, 50 minutes treadmills or/and ellipticals, five minutes cool down RE: 60 minutes 3x per week Series of ten whole body exercises with fitness equipment (Leg press, Latissimus pull), push-ups and crunches.
Results	Baseline: n = 37 BMI (kg/m^2) AE 32.9 ± 3.8 , RE 36.4 ± 3.8 . After three months: n = 37 BMI (kg/m^2) AE 32.44 ± 0.58 , RE 36.12 ± 0.54 .
Design	RCT
Assessment	PEDro-Scala: 6/10

The following study by Maddison et al [17] occurred over six months with 322 volunteers. The intervention is only poorly described. When the BMI was measured after 12 weeks, the study result showed a reduction of the BMI by $0.7 \text{ kg}/\text{m}^2$ and a further reduction by $0.1 \text{ kg}/\text{m}^2$ after 24 weeks. This means a reduction of $0.8 \text{ kg}/\text{m}^2$ favored the intervention group (-0.24 ; 95% CI: -0.44 , -0.05 ; $p = 0.02$). The number of volunteers changed during the intervention and decreased to only 231. There was also a not significant reduction in body fat in the intervention group (-0.83% ; 95% CI: -1.54% , -0.12% ; $p = 0.02$). Maddison et al recommended active video game as it has a slight but definite effect on BMI and body composition (Table 6).

Table 6. Study characteristics [17]

Title	Effects of active video games on body composition: a randomized controlled trial
Author/ Year	Maddison et al, 2011
Length of study	Six months
Number and age of participants	322 children with obesity and overweight (10-14 years) (intervention group n = 160, control group n = 162)
Measured values	BMI (kg/m ²), body fat, physical activity, heart-lung-fitness
Intervention	60 minutes moderate till strong physical activity on many days of the week, additionally during the inactive periods playing of active video games. In total received the children five different video games.
Results	Baseline: n = 322 BMI (kg/m ²) 25.6 ± 4.1 After 12 weeks: n = 245 BMI (kg/m ²) 24.9 ± 4.0 After 24 weeks n = 231 BMI (kg/m ²) 24.8 ± 3.6
Design	RCT
Assessment	PEDro-Scala: 6/10

Weintraub et al [14] investigated the effect of 75 minutes of playing football after school (Table 7). In a group of 21 volunteers, nine of whom were in the intervention group, played soccer three to four times a week after school and reduced their BMI by 0.05 kg/m² after three months. After six months, the BMI increased by 0.22 kg/m² in comparison to the beginning of the study. The authors stated: “compared with children receiving health education, children in the soccer group had significant decreases in body mass index z scores at 3 (p= 0.03) and 6 months (p=0.04) and significant increases in total daily, moderate, and vigorous physical activity at 3 months.”

Table 7. Study characteristics [14]

Title	Team sports for overweight children: the Stanford Sports to Prevent Obesity Randomized Trial (SPORT)
Author/ Year	Weintraub et al, 2008
Length of study	Six months
Number and age of participants	21 children with obesity (85. percentile) (from class 4-5) (intervention group n = 9, control group n = 12)
Measured values	BMI, number of steps, physical activity
Intervention	Playing football after school for 75 minutes 3-4 x per week. Warm up at the beginning and stretching at the end.
Results	Baseline: BMI (kg/m ²) 27.17 After three months: BMI (kg/m ²) 27.12 After six months: BMI (kg/m ²) 27.39
Design	RCT
Assessment	PEDro-Scala: 5/10

A 24-month study was conducted by Savoye et al [13] 174 volunteers with a percentile above 95 participated, 105 of them in the intervention group. The intervention remained the same for 12 months but varied during the intervention period, which doubled after six months. No active interventions were carried out during the last 12 months of the study. It was a high-intensity training in which the volunteers should train at a heart rate between 65% and 80% of the individual maximum frequency. In addition, three more days should be trained at home. The study result could only be measured by 45 volunteers, the BMI value was -0.1 kg/m² after 24 months. The

conclusion of this study reveals that the benefits of an intensive therapy program can be sustained 12 months after completing the intervention phase (Table 8).

Table 8. Study characteristics [13]

Title	Long-term results of an obesity program in an ethnically diverse pediatric population
Author/ Year	Savoie et al, 2011
Length of study	24 months
Number and age of participants	174 children with obesity (> 95. percentile) (8-16 years) (intervention group n = 105, control group n = 69)
Measured values	BMI, blood pressure, body fat, cholesterol
Intervention	100 minutes per week during the first 6 months, 200 minutes per week during the next 6 months. Warm up, high-Intensity-Training/ 65% - 80% of the heart frequency (aerobic exercises, child games, obstacle course, basketball, football, sprint games), cool-down. Additionally, were the volunteers encouraged to train on three more days a week. In the last 12 months was no activity interventions carried out.
Results	Baseline: n = 105 BMI (kg/m ²) 35.7 After 24 months: n = 45 BMI (kg/m ²) 35.6
Design	RCT
Assessment	PEDro-Scala: 6/10

Discussion

Due to the different number of volunteers, the duration and frequency and the type of intervention, the studies could be compared badly. The inconsistency differentiation, as well as the lack of differentiation between obesity and overweight in the individual studies, also made comparison difficult. The study by Lee et al [16] achieved the most effective reduction of BMI (-0.46 kg/m²) with training on treadmills and ellipticals for 60 minutes on three days of the week over a period of three months. The least effective intervention was playing football after school, by Weintraub et al [14], where the BMI value increased by 0.22 kg/m². These differences can be caused by different interventions, the frequency of training, the duration of the intervention and the training intensity are playing an important role. The low number of volunteers (nine children with obesity in the intervention group) can also be responsible for the significantly divergent results. The result of a further study with 48 children with obesity, in which a reduction of the BMI value by -0.48 kg/m² could be achieved by means of various video games over 2½ months supports this [18].

All studies describe different training programs and recommendations to achieve weight reduction. Not only a reduction in the BMI value could be achieved with 4 out of 5 studies with the help of movement therapy interventions, at the same time it also led to better fitness and lower body fat mass. In general, it is seen as crucial that the children who participate in the interventions with fun and can achieve better results. Usually, training programs are designed in such a way that through endurance training and coordination training the capability improves. However, the evidence of the included studies was very general, and it was hardly possible to make a conclusive statement on motor skills.

The current opinion that movement therapy for children with obesity leads to a weight reduction if the training is carried out regularly and protracted, cannot be confirmed to 100% by the data presented here.

None of the studies planned to analyze the effectiveness of the treatments in the long term. Regular investigations until the adult age would be desirable. So, it could be shown how the treatment of childhood obesity affects the development in the adult age.

Other studies report interdisciplinary interventions. This implicates treatments which perform more than one intervention, e.g. sports in combination with movement, school-based interventions, behavioral training combined with exercise, and nutritional advice or interventions with the parents.

Voller et al [19] conclude that a short-term weight reduction by a diet can be achieved more effectively than by motion therapy. However, long-term success can be achieved with combined intervention programs. For children, it is important to remember that they are still growing and that no drastic diets should be taken which could lead to further health risks [20]. In order to ensure normal development of

the child, only a dietary energy reduction was recommended for a long time [21]. In addition to this older literature, there are also current publications that question the calorie reduction alone as a one-dimensional approach [22,23].

Since there is still little knowledge about an effective therapy for children and adolescents with obesity and there are only a few evidence-based recommendations in the literature, guidelines for the treatment for children with obesity are included in "Consensus-Based (S2) Guideline for the Diagnosis, Therapy and Prevention of Overweight and Obesity in the childhood and adolescence" [24]. The primary goal is the long-term sportive activity, which is more effective in terms of weight reduction than a time-limited sports program.

Conclusion

Through the five included studies, a very small reduction in BMI was shown in four of the cases (in which the only one was double-blinded), with an increase in one study. The movement interventions included various exercises to improve endurance, strength, coordination, and other motor skills. However, the extent of which range is the most effective must be borne out in future research. This study shows what evidence we do have at present and where we must go in the near future. The most promising are the interventions, which will enable multidisciplinary measures and long-term care for patients. The networking of outpatient and inpatient measures is also useful [24]. A general and permanent change in the movement and nutritional behavior is to be achieved and demonstrated by the social environment. In the future, the interdisciplinary collaboration will have to provide qualitative and quantitative studies to improve interventions and their effectiveness.

Conflict of interest

There are no financial or other conflicts of interest related to the submitted manuscript.

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