Weight Loss and Improved Gross Motor Coordination in Children as a Result of Multidisciplinary Residential Obesity Treatment

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This study evaluated the short-term effectiveness of a multidisciplinary residential obesity treatment program by describing changes in body weight, related measures, and gross motor co-ordination. Secondarily, it was examined to what extent the amount of relative weight loss achieved by overweight and obese (OW/OB) participants explained the projected improvement in gross motor co-ordination. Thirty-six OW/OB children (aged 10.5 ± 1.4 years, 12 girls and 24 boys) were recruited at the Zeepreventorium VZW (De Haan, Belgium), where they followed a specific program consisting of moderate dietary restriction, psychological support, and physical activity. For reference purposes, an additional group of 36 age- and gender-matched healthy-weight (HW) children was included in the study. Anthropometric measures were recorded and gross motor co-ordination was assessed using the Körperkoordinationstest für Kinder (KTK) on two occasions with an interval of 4 months. Regardless of the test moment, OW/OB participants displayed significantly poorer KTK performances ($P < 0.001$). However, treatment was found to be efficacious in decreasing body weight (Δ 17.9 ± 3.1%, $P < 0.001$) and generating a significant progress in gross motor co-ordination performance, with a greater increase in KTK score(s) from baseline to re-test as compared to HW peers ($P < 0.01$). Within the OW/OB group, the amount of relative weight loss explained 26.9% of the variance in improvement in overall KTK performance. Therefore, multidisciplinary residential treatment and concomitant weight loss can be considered an important means to upgrade OW/OB children's level of gross motor co-ordination, which in turn may promote physical activity participation.

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INTRODUCTION

The prevalence of childhood overweight (OW) and obesity (OB) has been rapidly increasing worldwide (1). This global epidemic is alarming because OW and OB in children has been associated with a number of negative outcomes concerning physical health and psychosocial well-being along with an increased risk for persistence into later adulthood (2,3). In recent years, the adverse implications of being OW or obese (OB) on children's level of motor skill competence has received increasing attention given the potential role of this factor in both development (prevention) and treatment (intervention) of the condition (4–8).

Successful engagement in everyday activities requires that children master different motor skills, ranging on a continuum from gross to fine motor co-ordination (9,10). Furthermore, motor skill competence is considered a key determinant of physical activity engagement (11–13). Children with a high level of motor competence may find it easier to participate in physical activity, whereas children with a low(er) level of motor competence may prefer more sedentary pastimes in order to avoid movement difficulties (14–16). Such activity deficit may lead to limited movement experiences, which impedes the necessary practice and further development of motor skills as well as health-related benefits (7,15,16). Because adequate motor competence may assist in maintaining a physically active lifestyle, a lack thereof puts less skilled children at risk for developing OW or OB (16,17).

At the same time, a growing body of evidence has shown that excess body weight imposes significant constraints on children's motor competence (4,18–24). The majority of available studies within this particular area of research have predominantly focussed on gross motor skills and associated body co-ordination, which clearly seemed to be affected. Graf *et al.* (20), for example, demonstrated an inverse relationship between BMI and gross motor development in a large sample of first-grade

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children. Childhood OW and especially OB were found to result in poorer gross motor co-ordination performance as compared to healthy-weight (HW) peers. Moreover, D'Hondt *et al.* (23) reported a more pronounced detrimental effect of excess body weight on gross motor co-ordination with increasing age in 5- to 12-year old children. Remarkably, most OW and OB (OW/OB) children do not only show motor skill competence that deviates from the normative standards, but that can also be classified as impaired requiring special attention (23,24). As OW and OB are strongly associated with nonoptimal motor development, weight status proves to be an important factor explaining variation in children's motor competence levels.

Accordingly, OB treatment (and concomitant weight loss) may have a beneficial effect on motor skill in OW/OB children. It seems increasingly apparent from adult and adolescent literature that weight loss is associated with significant improvements in muscle function, motor control, and performance (25,26). In children, however, research has mainly focussed on the effectiveness of weight reduction programs in decreasing body fat levels and improving measures of (mental) health, physical activity, and physical fitness performance (27–30). Studies examining whether (relative) weight loss achieved by following a multidisciplinary OB treatment program may also improve OW/OB children's motor skill competence and co-ordination are currently lacking.

The main purpose of the present preliminary study was to evaluate the short-term effectiveness of an existing multidisciplinary residential treatment program for OW/OB children in terms of changing body weight and other weight-related measures as well as gross motor skill co-ordination. It was hypothesized that improvements would occur in both areas relative to the baseline measures at the start of treatment. Given that the amount of (relative) weight loss achieved can be considered as a key outcome measure of the program, our secondary purpose was to describe the extent to which this factor explained the projected increase in participant's gross motor co-ordination performance. The greatest progress in gross motor co-ordination was expected in those children who lost the largest percentage of their original body weight during treatment.

METHODS AND PROCEDURES

Study population

A total of 72 children (aged 7–13 years, 24 girls and 48 boys) participated in this study. Half of the children ($N = 36$) was recruited through a local rehabilitation centre (Zeepreventorium VZW, De Haan, Belgium), where they attended a multidisciplinary residential OB treatment program (between January 2008 and July 2009). Based on internationally accepted cut-off points for BMI in children (31), these participants could be identified as OW ($N = 2$) or OB ($N = 34$) and were assigned to the OW/OB group. All of the OW/OB children were referred to the program by their family physician, but had no underlying endocrine disease and were free from any serious comorbidities. A normal intelligence quotient (i.e., IQ >70) was an additional criterion for entry in the program. The other 36 children included in this study were recruited through a local primary school (in October 2009) and selected from a larger pool of around 200 pupils in order to match the OW/OB participants based on gender and age. These participants could all be classified as HW and represented the HW group, which was not involved in any kind of treatment. The study sample was further divided into a younger (aged 7–9 years, $N = 26$) and an older group (aged 10–13 years, $N = 46$), with weight status evenly distributed in both age groups (50% HW and 50% OW/OB).

OB treatment program

Participants in the OW/OB group followed a multidisciplinary residential treatment program at the Zeepreventorium VZW, with a standard duration varying from 6 to 10 months and a minimal treatment period of 4 months. The program consisted of three major components, including moderate dietary restriction (i.e., 1,400–1,600 kcal/day from three main meals and two healthy snacks), psychological support (i.e., cognitive behavioral modification and individual psychotherapy), and regular physical activity. Concerning this latter component, each child received 4 h/week of individual guided exercises with a focus on aerobic activities such as walking, running, swimming, cycling, or fitness training. Activities were performed at an exercise intensity of 20% lower than the theoretical maximal heart rate and exercise duration gradually increased during treatment. Besides improving endurance, exercise sessions were also focused on the correction of posture and the maintenance of flexibility and muscular strength. In addition, children participated in organized/supervised team sports and/or group games for 2 h/day or 10 h/week and had also sufficient opportunity to be physically active in their free time.

Measurements

All children were assessed on two occasions, with a time interval of 4 months. Evaluation at baseline occurred during the first month of the residential treatment program for those participants included in the OW/OB group. At both testing sessions, children wore light sportswear and were barefoot. Anthropometric measures were always recorded prior to the assessment of gross motor co-ordination. All tests were administered by a team of trained examiners. The study protocol was approved by the Ethics Committee of the Ghent University Hospital, and written informed consent was obtained from the parent(s) of each of the participants prior to data collection.

Anthropometric measurements

Height was measured to the nearest 0.1 cm using a portable stadiometer (Harpenden; Holtain, Crymych, UK). Body weight (0.1 kg) and percentage body fat (0.1%) were computed using a digital balance scale provided with foot-to-foot bioelectrical impedance analysis technology (Tanita BC-420; Weda, Naarden, Holland), which has been shown to be a reliable and accurate tool for the measurement of body composition in children (32,33). From the recorded height and weight measures, BMI (kg/m^2) was calculated and used to classify the subjects according to the age- and gender-specific BMI cut-off points for children recommended by the International Obesity Task Force (31). Waist circumference was measured with 0.1 cm accuracy at 4 cm above the umbilicus using a flexible nonelastic tape (34).

Assessment of gross motor co-ordination

Gross motor co-ordination was assessed by means of the Körperkoordinationstest für Kinder (Body Co-ordination Test for Children) (KTK). It is a standardized product-oriented test, developed and recently revised by Kiphard and Schilling (35,36). Being a highly reliable and valid instrument, the KTK is commonly used to asses gross motor and dynamic balance skills in children aged 5–15 years (35–37). The test battery was also designed to identify children facing gross motor co-ordination problems.

Administration of the KTK requires four subtests to be completed: (i) walking backwards along balance beams of decreasing width: 6.0 cm, 4.5 cm, 3.0 cm (KTK_{BEAM}), (ii) moving sideways on wooden boards during 20 s (KTK_{BOARD}), (iii) one-legged hopping over a foam obstacle with increasing height in consecutive steps of 5 cm (KTK_{HOP}), and (iv) two-legged jumping from side to side during 15 s (KTK_{JUMP}).

Based on the performance of a German standardization sample, the KTK manual provides tables containing normative data. Hence, the raw

performance score of each subtest can be converted into a standardized score adjusted for age (all four subtests) and gender (KTK_{HOP} and KTK_{JUMP}). Adding together all standardized scores results in an overall motor quotient (MQ), that can be converted into a percentile score. Not only does this allow the comparison of a child's performance with regard to that of peers in the reference population, the KTK manual also provides a classification into five different levels of gross motor co-ordination: (i) "high" (≥99th percentile), (ii) "good" (85th–98th percentile), (iii) "normal" (16th–84th percentile), (iv) "moderate motor impairment" (3rd–15th percentile), and (v) "severe motor impairment" (<3rd percentile). Accordingly, a child with an overall KTK performance equal or below the 15th percentile faces gross motor co-ordination problems and is actually in need of special attention (35,36).

Statistical analysis

Data were analyzed using the statistical package SPSS 16.0 for Windows (SPSS, Chicago, IL). Descriptive statistics (mean ± s.d.) were calculated for anthropometric measurements and KTK outcome, including the raw performance score on each subtest as well as the overall KTK MQ. Anthropometric characteristics were analyzed in a 2 (Time: baseline vs. after 4 months) × 2 (BMI group: HW vs. OW/OB) ANOVA with repeated measures on the first factor in order to determine BMI group differences and to verify the effectiveness of the residential treatment program. To examine the change in gross motor co-ordination performance over time and to investigate the effects of BMI group, age, and gender, all KTK variables were implemented in a 2 (Time: baseline vs. after 4 months) × 2 (BMI group: HW vs. OW/OB) × 2 (Age: 7–9 years vs. 10–13 years) × 2 (Gender: boys vs. girls) ANOVA with repeated measures on the first factor. Significant effects were further examined by means of independent- or paired-samples *t* tests. In addition, Pearson χ^2 analyses were conducted to have a closer look at the proportion of children in each BMI group showing motor impairment at baseline and the moment of retesting, using the 15th percentile as a cut-off point for overall KTK performance. Finally, within the OW/OB group, simple linear regression analysis was performed to investigate the variance in improvement in gross motor co-ordination performance explained from the amount of relative weight loss as a result of multidisciplinary residential treatment. Therefore, the absolute value of the difference in overall KTK MQ (Δ KTK MQ) was implemented as the dependent variable, whereas the amount of weight loss expressed relative to the children's original weight at baseline (%) was used as the independent variable. For all analyses, values of $P < 0.05$ were considered statistically significant.

RESULTS

Anthropometric measurements

Detailed anthropometric characteristics are presented in Table 1. There was a significant interaction between Time and BMI group for weight ($F_{(1,70)} = 496.260$, $P < 0.001$), BMI ($F_{(1,70)} = 745.580$, $P < 0.001$), BMI *z*-score ($F_{(1,70)} = 168.038$, $P < 0.001$), percentage body fat ($F_{(1,70)} = 278.201$, $P < 0.001$), and waist circumference ($F_{(1,70)} = 66.468$, $P < 0.001$). Results indicated a significant decrease for each of these weight-related measures in the OW/OB group ($t_{(35)} = 8.174 – 28.672$, $P < 0.001$) after 4 months of residential treatment. In the HW group, weight ($t_{(35)} = 7.444$, $P < 0.001$) and BMI ($t_{(35)} = 3.173$, $P = 0.003$) slightly increased, whereas BMI *z*-score ($t_{(35)} = 1.050$, $P = 0.301$), percentage body fat ($t_{(35)} = 1.090$, $P = 0.283$), and waist circumference ($t_{(35)} = 1.315$, $P = 0.197$) remained constant over time.

All children that were classified as HW at baseline maintained the same weight status after the set time interval of 4 months between testing sessions. After a mean weight loss of 11.7 ± 3.3 kg among participants within the OW/OB group at the moment of retesting, four children (i.e., two OW and two OB) could now be identified as HW, 21 children could be classified as OW, and 11 children were still OB (31). (In the interest of clarity, the original BMI-related group names (i.e., HW group and OW/OB group) were used throughout the paper even though the weight status of some OW/OB participants changed over time).

Change in gross motor co-ordination over time

Descriptive statistics of the raw performance scores on each of the four subtests as well as the overall KTK MQ are presented in Table 2. As no significant four- or three-way interactions were found, Table 3 only shows the *F*-values of main and two-way interaction effects resulting from the repeated measures ANOVA analysis. Only the statistical outcomes most pertinent to our main research question are discussed below.

Each of the KTK variables was featured by a significant main effect of Time, indicating that all participants' gross motor co-ordination performance had improved from baseline to re-test. More importantly, significant interactions between Time and BMI group (except for KTK_{BOARD}) demonstrated that the increase in KTK scores over time was larger for the OW/OB participants, who participated in multidisciplinary residential treatment during the 4-month period between testing sessions (see Figure 1 for overall KTK MQ). There was also a significant main effect of BMI group for each of the four subtests as

Table 1 Descriptive statistics (mean ± s.d.) for the HW and the OW/OB group

Anthropometric characteristics	Baseline		After 4 months	
	HW (*N* = 36)	OW/OB (*N* = 36)	HW (*N* = 36)	OW/OB (*N* = 36)
Age (years)	10.5 ± 1.4	10.5 ± 1.4	10.9 ± 1.4	10.9 ± 1.4
Height (cm)	142.6 ± 9.7[a]	149.0 ± 9.6[b]	144.9 ± 9.7[c]	150.8 ± 9.8[d]
Weight (kg)	35.0 ± 6.7[a]	65.0 ± 13.4[b]	36.9 ± 7.4[c]	53.3 ± 10.8[d]
BMI (kg/m²)	17.08 ± 1.72[a]	29.08 ± 3.60[b]	17.38 ± 1.82[c]	23.29 ± 2.86[d]
BMI *z*-score	–0.05 ± 0.68[a]	2.41 ± 0.34[b]	–0.01 ± 0.68[a]	1.63 ± 0.48[c]
Body fat (%)	16.98 ± 4.39[a]	38.24 ± 7.72[b]	16.68 ± 4.63[a]	27.50 ± 7.19[c]
Waist circumference (cm)	60.0 ± 4.9[a]	89.3 ± 13.9[b]	60.7 ± 5.5[a]	75.4 ± 8.5[c]

HW, healthy-weight group; OW/OB, overweight/obese group.
[a,b,c,d]Means with different letters are significantly different from each other (resulting from independent- or paired-samples *t* tests).

Table 2 KTK performance (mean ± s.d.) for participants in the HW and the OW/OB group

		7–9 Years (*N* = 26)				10–13 years (*N* = 46)			
		HW		OW/OB		HW		OW/OB	
Gender	KTK variables	Baseline	After 4 months	Baseline	After 4 months	Baseline	After 4 months	Baseline	After 4 months
Boys	KTK_{BEAM}	35.00 ± 9.27	51.50 ± 4.89	18.33 ± 10.39	31.83 ± 10.72	46.44 ± 10.61	51.00 ± 9.04	21.50 ± 13.74	30.06 ± 12.85
	KTK_{BOARD}	39.67 ± 5.96	39.17 ± 6.24	30.00 ± 6.57	32.50 ± 5.09	45.11 ± 7.05	48.56 ± 4.74	34.56 ± 9.51	41.28 ± 85.51
	KTK_{HOP}	58.50 ± 11.61	63.83 ± 13.39	18.50 ± 15.15	40.67 ± 15.03	68.56 ± 7.63	71.94 ± 6.82	33.28 ± 12.70	55.50 ± 15.40
	KTK_{JUMP}	49.83 ± 8.98	53.50 ± 5.86	34.83 ± 12.64	45.17 ± 16.18	68.39 ± 12.25	71.89 ± 8.77	42.50 ± 13.25	56.50 ± 10.85
	Overall KTK MQ	99.17 ± 15.24	102.50 ± 12.11	61.17 ± 13.59	81.00 ± 15.34	98.50 ± 15.80	104.33 ± 13.12	57.50 ± 19.14	73.89 ± 19.81
Girls	KTK_{BEAM}	47.43 ± 13.18	54.71 ± 11.01	14.86 ± 9.55	23.14 ± 14.17	55.20 ± 6.30	53.40 ± 6.19	19.80 ± 5.81	34.80 ± 12.01
	KTK_{BOARD}	46.29 ± 7.91	50.57 ± 7.30	27.43 ± 8.18	34.43 ± 6.24	50.80 ± 7.23	56.60 ± 4.04	36.40 ± 4.28	40.80 ± 3.42
	KTK_{HOP}	59.29 ± 14.00	62.71 ± 11.60	15.43 ± 9.00	30.57 ± 13.30	69.80 ± 2.95	71.20 ± 7.09	30.40 ± 8.08	46.40 ± 12.68
	KTK_{JUMP}	71.00 ± 15.93	70.43 ± 12.83	33.29 ± 9.64	43.14 ± 13.08	74.40 ± 4.72	78.00 ± 5.34	37.40 ± 10.07	50.80 ± 18.85
	Overall KTK MQ	113.29 ± 21.63	113.14 ± 23.13	55.15 ± 15.66	68.57 ± 15.95	108.40 ± 6.35	112.60 ± 6.35	56.60 ± 11.87	66.00 ± 16.85

HW, healthy-weight group; KTK, Körperkoordinationstest für Kinder; MQ, motor quotient; OW/OB, overweight/obese group.

Table 3 Main and two-way interaction effects for KTK performance according to time, BMI, age, and gender

KTK variables	F_{TIME}	F_{BMI}	F_{AGE}	F_{GENDER}	$F_{TIME \times BMI}$	$F_{TIME \times AGE}$	$F_{TIME \times GENDER}$	$F_{BMI \times AGE}$	$F_{BMI \times GENDER}$	$F_{AGE \times GENDER}$
KTK_{BEAM}	39.42***	80.33***	4.57*	1.70	8.54**	0.88	0.19	0.20	4.67*	0.01
KTK_{BOARD}	20.13***	57.75***	17.09***	6.17*	1.02	0.89	1.54	0.06	5.63*	0.03
KTK_{HOP}	176.97***	116.62***	17.06***	1.12	85.67***	0.21	6.55*	0.97	1.15	0.01
KTK_{JUMP}	43.39***	68.75***	11.33**	2.53	18.17***	1.63	0.35	0.54	7.64**	2.02
Overall KTK MQ	44.93***	98.15***	0.23	0.22	18.06***	0.01	2.95	0.05	4.38*	0.01

KTK, Körperkoordinationstest für Kinder; MQ, motor quotient. ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$.

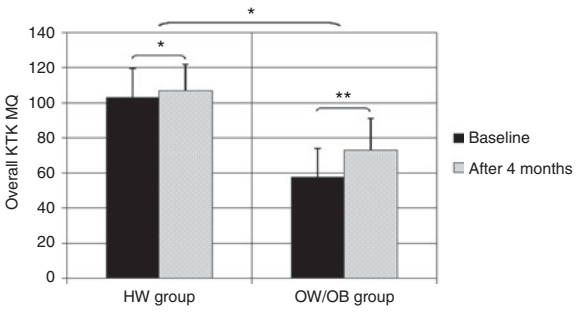

Figure 1 Overall motor quotient (MQ) on the Körperkoordinationstest für Kinder (KTK) at baseline (black blocks) and after a (treatment) period of 4 months (gray blocks) for the healthy-weight (HW) group and the overweight/obese (OW/OB) group. Vertical bars represent standard deviations. Significant differences are indicated by asterisks.

well as overall KTK MQ. Regardless of the test moment, poorer gross motor co-ordination performance was observed among participants in the OW/OB group compared to peers in the HW group.

Using the 15th percentile as a cut-off point, the proportion of children who showed moderate to severe motor impairment at baseline was 16.7% in the HW group and 94.4% in the OW/OB group ($\chi^2 = 44.100$, $P < 0.001$). At the moment of retesting, only one child within the HW group and five children within the OW/OB group made the transition from impaired to normal or high levels of gross motor co-ordination. Nevertheless, ratios were still significantly different between BMI groups after a (treatment) period of 4 months with 13.9% of the participants in the HW group and 80.6% of the participants in the OW/OB group facing gross motor co-ordination problems ($\chi^2 = 32.099$, $P < 0.001$).

Weight loss (%) and improved gross motor co-ordination within the OW/OB group

Simple linear regression analysis was performed to investigate the relationship between the amount of relative weight loss (i.e., independent variable) and the degree of change in overall KTK performance (i.e., dependent variable) from baseline to re-test in the participants following the multidisciplinary residential treatment program. Additional residual analysis revealed that model assumptions for linear regression were met. After 4 months of OB treatment, the OW/OB children had lost on average 17.9 ± 3.1% of their original weight at baseline. The amount of relative weight loss achieved explained 26.9% of the variance in improvement observed in overall KTK performance ($f_{(\Delta \text{ KTK MQ})} = -17.032 + 1.814$ weight loss (%), $R^2 = 0.269$, $P = 0.001$).

DISCUSSION

The present preliminary study evaluated the short-term outcomes of an existing multidisciplinary residential treatment program for OW/OB children in terms of body weight, other weight-related measures, and gross motor skill co-ordination. Results demonstrate that the specific program provided by the Zeepreventorium VZW (De Haan, Belgium) is efficacious in realizing considerable weight loss as well as generating a significant progress in gross motor co-ordination performance after 4 months of residential treatment. In addition, verification of a linear relationship between both changes suggests that the degree of improvement in OW/OB children's gross motor co-ordination can be partly explained by the amount of relative weight loss achieved.

In first instance, this study adds to the evidence from previous reports regarding the effectiveness of multidisciplinary residential treatment in the specific setting of the Zeepreventorium VZW in substantially decreasing levels of OW and body fat (27,28,38). After an initial treatment period of 4 months, we found a significant reduction in all weight-related measures (i.e., body weight, BMI (*z*-score), percentage body fat, and waist circumference) for participants in the OW/OB group. The program, which consisted of moderate dietary restriction, psychological support, and regular physical activity, resulted in a mean absolute weight loss of 11.7 kg, corresponding to 17.9%, of these children's original weight at baseline. Previous studies have shown that the particular OB treatment program provided by the Zeepreventorium VZW is also successful in enhancing psychosocial well-being (27), improving aerobic fitness (28), and treating sleep-disordered breathing through weight loss (38). Hence, our study provides additional information since it was not yet investigated whether and to what extent this kind of multidisciplinary residential treatment and the amount of weight loss achieved may have a beneficial effect on OW/OB children's gross motor skill co-ordination.

Using the KTK as an assessment tool, it was demonstrated that all participants' gross motor co-ordination performance significantly progressed within the timeframe of 4 months. This gradual improvement in gross motor skill co-ordination is not surprising as it appears to be a general phenomenon across developmental time (39). More importantly, a closer inspection of our data revealed a significantly greater increase in KTK outcome scores from baseline to re-test for the OW/OB group of children as compared to their peers included in the HW group. In other words, the improvement in gross motor co-ordination performance among the OW/OB participants exceeded the progress that can be expected with reference to normal motor development. This is a key finding in view of previous cross-sectional research indicating a widening gap between the KTK performances of HW and OW/OB children, with a more pronounced detrimental effect of childhood OW and OB with increasing age if no action is taken (23). Accordingly, our results are a first indication that the likely further deterioration of OW/OB children's gross motor co-ordination over developmental time can be stopped and even compensated for by means of an overall multidisciplinary residential treatment.

Although participants in the OW/OB group were able to partially catch up their gross motor co-ordination deficit compared to HW peers, they still showed significantly poorer KTK performances after 4 months of treatment, regardless of the subtest under study. Looking at the proportion of children that could be classified as being motor impaired based on the set standards, 94.4% of the OW/OB participants had an overall KTK performance equal or below the 15th percentile at the start of the program. After 4 months of residential treatment, this proportion was only reduced to 80.6%. The fact that the majority of children within the OW/OB group did not achieve normalization of their body weight at the moment of retesting may have contributed to this finding. Regardless of the test occasion (i.e., at baseline or after 4 months), the observed percentages exceed the previously reported 70.8% of OW/OB children facing gross motor co-ordination problems in a study investigating the relationship between weight status and motor impairment using the same KTK standards in a school based setting (23). However, it should be noted that in the present study the prevalence of gross motor impairment was estimated in a clinical setting of OW/OB participants. As hypothesized and previously suggested, the degree of excess weight and/or corpulence appears to be a crucial factor adversely affecting motor competence in children when performing the tasks that are part of motor skill assessment batteries (22).

Therefore, it seemed appropriate to verify whether the amount of relative weight loss achieved by following the multidisciplinary residential treatment program at the Zeepreventorium VZW had an impact on the degree of improvement in gross motor co-ordination within the group of OW/OB children. Results of the corresponding simple linear regression analysis pointed out that 26.9% of the variance in improvement in overall KTK performance may be explained by the percentage of weight loss achieved after 4 months of residential treatment. Based on the regression equation, each lost percentage of OW/OB participants' original weight at baseline predicted an improvement of approximately two points in their overall KTK MQ. Furthermore, it can be assumed that the greatest improvement in gross motor co-ordination performance does indeed occur in the OW/OB children with the largest relative weight reduction. To our knowledge, this is the first study to show a beneficial effect of multidisciplinary OB treatment on OW/OB children's gross motor co-ordination, also describing the extent to which the amount of concomitant weight loss (%) achieved by the participants may explain part of their significant progress in performance. The observed positive relationship between the degree of weight reduction and the improvement in overall KTK MQ indicates that weight loss represents an important factor in promoting OW/OB children's motor skill competence.

A number of limitations need to be considered when interpreting the findings of the present preliminary study. Participants included in the OW/OB group were involved in a specific multidisciplinary residential treatment program, with gradually increasing physical activity as one of the key components in support of achieving a healthy weight. In view

of previous research establishing a reciprocal positive relationship between physical activity and motor competence (14,15,17,18,20), it should be noted that the increased involvement in various physical activities during the course of treatment provided the OW/OB children with great opportunities for the development of their (gross) motor skill co-ordination. Therefore, the amount of physical activity included in the program may have interacted with the outcome measure (relative) weight loss in explaining (part of) the improvement in overall KTK performance within the OW/OB group. Unfortunately, the actual level of participants' physical activity participation was not effectively measured. This lack of objective quantitative data prevented to control for this likely confounder in our statistical analyses. Future research is thus necessary to further explore the separate and/or combined effect of the factors potentially contributing to the reported progress in motor skill competence among children treated for OB. The absence of an additional control group of free-living children also matched for weight status (OW/OB) represents another shortcoming of this study. More than likely, the inclusion of a no treatment group of OW/OB children would have added to its demonstrative power in attributing the considerable increase in gross motor co-ordination performance to participation in multidisciplinary residential treatment (and concomitant weight loss) in contrast to growth induced motor development. Furthermore, the previous assumption of a widening disparity between the gross motor co-ordination performance of HW and OW/OB children not being involved in treatment could have been confirmed because of the longitudinal nature of the present study (23). In this respect, there would be a considerable surplus value in the evaluation of the longer-term effectiveness of the examined multidisciplinary OB treatment program in terms of decreasing body weight and improving gross motor skill co-ordination. Further follow-up studies will need to verify the occurrence and the persistence of the beneficial effects established after an initial treatment period of 4 months. In addition, the impact of maintained or continued weight loss vs. potential weight gain after the full program on children's level of motor competence remains to be investigated. The present study only focused on gross motor co-ordination as this aspect of motor competence seems to be the most affected by excess weight. However, there are recent indications for a possibly detrimental effect of childhood OW and OB on object control and/or fine motor skill performance too (22,24,40). Given that both features of motor competence determine a child's well-being, general development, and (later) physical activity behavior (6,9,10,12,37), future research in this specific area should explore motor functioning in all its aspects. Finally, it should be mentioned that our preliminary findings thus far only apply to the specific clinical setting of the local rehabilitation centre Zeepreventorium VZW (De Haan, Belgium), in which our study was conducted.

In conclusion, an existing multidisciplinary residential treatment program for OW/OB children was shown to be successful in realizing substantial weight loss and bringing about a remarkable increase in gross motor co-ordination performance in the short-term. The extent of improvement in gross motor co-ordination reflected in KTK scores was found to be linearly related to the amount of relative weight loss achieved by following the program for 4 months. Although the impact of other treatment-related factors that might contribute to the observed progress in motor competence was not specifically investigated in the present preliminary study, significant weight loss may be considered an important means to upgrade the level of gross motor skill in OW/OB children. Regardless thereof, the finding of improved gross motor co-ordination as a result of multidisciplinary residential OB treatment is paramount in view of the fact that it may assist in promoting sustained participation in physical activities.

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DISCLOSURE

The authors declare no conflicts of interest.

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