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Kühr, Petra; Antunes Lima, Rodrigo; Grøntved, Anders; Wedderkopp, Niels; Klakk, Heidi

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DR. RODRIGO ANTUNES LIMA (Orcid ID : 0000-0002-7778-2616)

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Three times as much physical education reduced the risk of children being overweight or obese after five years

Authors: Petra Kühr[1,2], Rodrigo Antunes Lima[3,4], Anders Grøntved[1], Niels Wedderkopp[1,5,6,7], Heidi Klakk[1,8]

Affiliations:

1 – Department of Sport Science and Clinical Biomechanics, Research Unit for Exercise Epidemiology, Centre of Research in Childhood Health, Faculty of Health, University of Southern Denmark, Denmark

2 – University of Rome, Faculty of Sport and Exercise Sciences, 135 Rome, Italy

3 – CAPES Foundation, Ministry of Education of Brazil, Brasília – DF, 70040-020, Brazil

4 – Institute of Sport Science, University of Graz, Graz, Austria

5 – Institute of Regional Health Research, University of Southern Denmark, 5230 Odense M, Denmark

6 – University of New Brunswick, Fredericton, New Brunswick, Canada

7 – Orthopedic dep. Hospital of Southwestern Jutland, 6700 Esbjerg, Denmark

8 – University College Lillebaelt, Faculty of Applied Health Science, Odense, Denmark

Short title: Effect of additional physical education lessons

Corresponding author: Rodrigo Antunes Lima; Arnóbio Marquês Street, 310, Recife, Brazil, Zipcode: 50100-130; rodrigoantlima@gmail.com

ABSTRACT

Aim

We evaluated the effect that increasing physical education lessons from 1.5 to 4.5 hours per week for five years had on the body mass index (BMI) and waist circumferences of children aged 5-11 years at inclusion.

Methods

From 2008-2013, six intervention schools in Svendborg, Denmark, delivered 4.5 hours of physical education lessons per week to 750 children. Meanwhile, four matched control schools gave 549 children the standard 1.5 hours of physical education lessons per week. Measurements were taken at baseline and after five years. Of the 1,299 children, 81 joined the schools after 2008. **Results**

At baseline, the percentage of overweight children was 12% in the intervention schools and 13% in the control schools, whereas 15% and 19% were abdominal obese, respectively. After five years, the respective risks of remaining abdominal obese or overweight were 43% and 51% in the intervention schools and 78% and 84% in the control schools. Mean BMI increased 0.450 kg/m^2 more in the control group over the five-year period. The intervention was not effective in decreasing the average waist circumference.

Conclusion

Three times as much physical education lessons per week, for five years, effectively decreased BMI and the likelihood of remaining overweight or obese.

KEY WORDS

Obesity, Overweight, Physical education, School-based intervention, Waist circumference

KEY NOTES

- We evaluated the effect of increasing physical education lessons from 1.5 to 4.5 hours/week for five years had on children's weight status
- In the control schools 78% of children with abdominal obesity at baseline remained abdominal obese, but in the intervention schools 43% remained abdominal obese after five years
- The mean body mass index increased by 0.450 kg/m2 more in the children in the control group over the five-year period.

INTRODUCTION

The increased prevalence of overweight and obesity has become a growing concern in public health (1). The most important long-term consequence of childhood obesity are adult obesity and the related health and disease problems, namely type 2 diabetes, cardiovascular diseases and various types of cancer (1). An important contributor to the high prevalence of overweight and obesity is low levels of physical activity (2). The World Health Organization has identified schools as an ideal setting for promoting physical activity in children and adolescents (3). Children and adolescents spend most of their waking hours at school, which makes it an ideal venue for activities that help them to avoid becoming overweight or obese or tackle existing problems (2).

Several studies have been conducted to analyse the effects of school-based physical activity interventions. The authors reported either positive effects (4–6) or no effects (7–9) on body mass index (BMI) and, or, waist circumference. Three meta-analyses and one systematic review showed no effect (10,11), or a lack of evidence (12,13) that school-based physical activity interventions had a positive effect on overweight and obesity. This could have been due to the fact that the studies showed great variations in the duration, intensity and type of physical activity used in the interventions. In contrast, Gonzalez-Suarez et al (14), Lavelle et al (15) and Mahmood et al (16) found that school-based interventions could be effective in reducing BMI or the prevalence of obesity. Studies have not identified the maximum duration of physical exercise that is required for an intervention to deliver the greatest impact. More research is needed to find the most effective way to prevent, or decrease, the number of overweight and obese children and to investigate if the effect was sustained several years later. Long-term follow up of school-based interventions could help to identify the most effective intervention strategies.

The aim of this study was to evaluate the effect that three extra hours of physical education lessons per week had on the BMI and waist circumference of school children who were aged 5-11 years at baseline. The data from the five-year intervention programme was compared with control schools who provided pupils with the standard 1.5 hours per week offered by Danish schools.

PATIENTS AND METHODS

Study design and ethics

The present study was part of the Childhood Health, Activity and Motor Performance School Study Denmark (CHAMPS DK) study. All 19 government funded schools in the municipality of Svendborg, Denmark, were invited to participate in the project by the municipality. Six of the schools agreed to be intervention schools and the municipality and researchers decided that this was an adequate number for the purposes of the study. We had hoped to recruit six matching control schools, but only four schools agreed to take part. The socioeconomic status of the control and intervention schools were comparable with regard to school size, uptake area, urban-suburban or rural area and the socioeconomic position of the parents. The 10 participating schools represented more than half of the government-funded schools in the municipality and only one child moved before the start of the study as the parents did not want them to participate. Detailed information on the implementation of the CHAMPS DK study has previously been reported (17,18).

The intervention lasted five years. The intervention schools provided four extra physical education lessons per week, in addition to the usual physical education programme for all children from pre-school to the fourth grade. These children, who were aged 5-11 years, got a minimum of 4.5 hours of physical education classes per week, including three sessions that lasted at least 60 minutes. The control schools continued to provide the regular physical education programme in Denmark, which lasted 1.5 hours per week.

The CHAMPS DK study formed part of a community initiative called the Svendborg project (17), which was a quasi-experimental study that started in 2008 (19). The overall aim of the present study was to determine the health effects of increased physical education on children who took part in age-appropriate physical education in government-funded schools in the municipality of Svendborg (17). The study was carried out in accordance with the Declaration of Helsinki. It was approved by the local scientific ethics committee (ID S20080047) and registered with the Danish Data Protection Agency

(J.nr. 2008-41-2240) (17). Parents had to give their written, informed consent and children gave verbal consent before being included in the study data.

The study included children who were in kindergarten, which in Denmark is five and six years of age, up to the fourth grade, when children were 10 and 11 years. The baseline year for the study was 2008. A total of 1,507 children were enrolled in the 10 schools that agreed to participate in the CHAMPS DK study. Of these, 289 children and parents did not agree to participate, which led to 1,218 participants (81%) at baseline. Figure S1 presents a flowchart of the number of participants in the study for each of the five years. Over the course of the study a number of children left and joined the intervention and control groups. Whenever possible, the 81 children who joined the intervention schools underwent the same assessments as those included at baseline in 2008. The total number of children included in the study at some point during the five-year period was 1,299.

At baseline, the children were examined with parent and child questionnaires, physical examinations and physical testing. Weight, height and waist circumference measurements were performed at baseline and twice a year during the first three years and once a year after that. The pubertal stage was measured at baseline and once a year. Before all the test rounds, experienced researchers conducted training workshops for all testers, who comprised Bachelor, Masters and PhD students from the University of Southern Denmark. The researchers tested their skills on fellow testers, with around 15 people in each test round, and performed the tests on children in similar age groups in schools outside of the Municipality of Svendborg. In addition, a detailed manual was provided for all measurements. Testers were not blinded to the school type.

Measurements

Height was measured to the nearest kilogram (kg) with a Seca 214 portable stadiometer (Seca Corporation, New Hampshire, USA) and weight to the nearest centimetre (cm) with a Tanita BWB-800S digital scale (Tanita Corporation, Tokyo, Japan). Both measurements were performed when the subjects were barefoot and their weight was measured wearing lightweight clothes. BMI was calculated using the formula: weight in kilograms divided by height in square metres.

The BMI standard deviation score (BMI-SDS) was computed based on the formula designed for Danish children (20). Overweight and obesity were defined by BMI according to International Obesity Task Force criteria (21), using the sex-specific and half-year precision protocol (21).

Waist circumference may serve as an easy and direct diagnostic measure to identify overweight and obese children at risk (22). As BMI cannot discriminate between relative changes in abdominal fat, waist circumference measurements may prove beneficial in this context (23). Waist circumference was measured to the nearest 0.5cm with a measuring tape at the umbilicus level after gentle expiration. Two measurements were performed and a third measurement was performed if the difference was more than 1cm. The average of the two closest measurements was calculated and used for the analysis. Abdominal obesity was defined by using the waist circumference cut-off points of Fredriks et al, which were based on data from 14,500 Dutch children (22).

Pubertal stage was obtained by self-assessment using the Tanner self-assessment questionnaire (24). Boys reported pubic hair development and girls reported breast and pubic hair development. These assessments were recorded in private. As there were very few children at stages four and five, pubertal stage was dichotomised into Tanner stages one, two and three, and Tanner stages four and five.

The educational level of the mother and the children's birthweight were obtained by questionnaires delivered to all parents during the first study year or later if the child joined the study after 2008. The educational level was categorised based on the Danish education system and categorized into five levels: primary and lower secondary education, general upper secondary education, vocational education and training, Bachelor degree and Masters or PhD degree.

Statistical methods

All statistics were performed using Stata version 13 (Statacorp, Texas, USA). Baseline descriptive statistics were calculated for children aged five to 11 years with complete baseline data. Chi-square tests and t-tests were used to analyse and test associations between school type and baseline characteristics.

Two linear regression models were estimated with generalised estimating equations, to evaluate any differences in how the overall tendency for mean BMI and waist circumference varied based on the amount of time the subjects were exposed to the intervention. In addition, linear regression models were estimated with generalised estimating equations to evaluate whether participants with a higher BMI-SDS at baseline were more affected by the intervention. Two other logistic regression models were estimated with generalised estimating equations to compare the prevalence of overweight and abdominal obesity with the time exposed to the intervention. In all the regression models the amount of time exposed to the intervention was a variable indicator.

All the generalised estimation equations were adjusted for their respective baseline measures of BMI or waist circumference, sex, pubertal stage, age and mother's educational level. All the models used the exchangeable correlation structure, since there were no differences in the estimates compared to the unstructured correlation structure. The robust standard errors option was used to avoid exceptionally small standard errors.

We predicted the likelihood of subjects being overweight (Figure 1) or abdominally obese during the study period (Figure 2), depending on the participants' weight status for each additional year the children were exposed to the intervention. In all the regression models, we observed an interaction between follow-up time and baseline weight status and this was verified by the Wald test. Some of the participants had missing data at some time points, but we still used some of their data for the GEE analysis.

RESULTS

The flow chart in Figure S1 shows the number of children that took part each year from 2008 to 20012. The number of subjects, with the percentage in the intervention group in brackets, were: 1,218 in the first year (57.2%), 1,205 in the second year (57.5%), 1,213 in the third year (57.5%), 1,204 in the fourth year (57.3%) and 1,198 in the fifth year (57.4%). During the study period, 62 children left the intervention school group and 53 joined. We do not know why the children left the intervention: this could have been due to moving to other schools or because children withdrew their consent. The respective number for the control schools were 39 and 28. The total number of children who took part in the study at any point during the five-year period was 1,299.

Table 1 shows the baseline characteristics of key variables by school type and gender for 1,178 (90.7%) of the 1,299 children who took part in the study during the five-year period. This represented 676/750 (90.1%) of the children in the intervention group and 502/549 (91.4%) of the children in the control group. The remaining students were absent when the baseline data were collected in the first year and in subsequent years as new pupils joined the schools. In the intervention group, 12.00% of the participants were overweight and 12.95% were overweight in the control group ($p>0.05$). In addition, 14.66% of the children in the intervention group had abdominal obesity and it was higher in the control group, at 18.73% ($p<0.05$). This difference in the prevalence of abdominal obesity was higher in both the girls and boys in the control group compared to the intervention group.

Maternal education did not differ between the intervention and control groups, with regard to mothers who finished their vocational education and training (53.7% versus 48.3%) and their Bachelor-level university education (33.4% versus 39.1%).

Effect of intervention on BMI and waist circumference

Mean BMI increased by 0.450 kg/m^2 (95% CI -0.896 to -0.004, p= 0.048) more in the control group than in the intervention group over the five-year study period. Figures S2a-d show a higher decrease in the BMI-SDS in participants in the intervention group who had a higher BMI-SDS at baseline. Throughout the study, participants with a BMI-SDS of above three at baseline showed a higher decrease in BMI-SDS levels compared to participants with a BMI-SDS between zero and one at baseline.

Moreover, those who participated in the intervention and were overweight at baseline had a lower risk of remaining overweight than the controls who were overweight at baseline: 51.0% (95% CI 0.32 to 0.69) versus 84.0% (95% CI 0.77 to 0.91), respectively (Figure 1).

In general, the intervention did not affect the participants' average waist circumference (beta = 0.282, 95% CI -1.150 to 1.714, p= 0.699). On the other hand, participants with abdominal obesity at baseline showed considerable decreases in waist circumference over the study period if participants were in the intervention than control group: 43.0% (95% CI 0.30 to 0.56) versus 78.0% (95% CI 0.72 to 0.84), respectively (Figure 2).

DISCUSSION

We evaluated the five-year effect of three hours of extra physical education lessons per week on the body composition of primary school children aged five to 11 years at baseline. The effect of the 4.5 hours provided by the six schools in the intervention group were compared with the standard 1.5 hours offered by the four control schools, which was the normal amount of physical education provided by Danish schools. Our overall findings showed that the intervention had a greater effect on average BMI, but there was no overall effect on average waist circumference during the five-year follow-up period. However, participants with abdominal obesity at baseline showed considerable decreases in waist circumference over the study period. We specifically noted that being exposed to the intervention meant that participants with higher BMI-SDS levels had a lower risk of remaining overweight. The findings also showed that those with general overweight exhibited higher decreases in BMI-SDS levels and that those with abdominal obesity had a lower probability of remaining abdominal obese. This means that the results suggested that there was evidence of a treatment effect. In fact, the additional physical education lessons have now been maintained for 10 years and implemented in all schools in the municipality. This includes the nine schools who initially opted out of providing the minimum 1.5 hours per week.

The study showed that the intervention effects reported by Klakk et al (7), based on data from a two-year cohort from 2008 to 2010, were increased when children received the intervention for an additional three years. Klakk et al (7) conducted their study on 632 of the children included in this study, who were eight to 13 years of age when the two-year study ended. Body composition was defined by BMI and the total body fat percentage. The analysis conducted by Klakk et al (7) showed no significant intervention effect on mean BMI (beta = -0.14, 95% CI -0.33 to 0.04) or total body fat percentage (beta = -0.08, 95% CI -0.65 to 0.49). In the present study, each additional year that the children were exposed to the intervention led to a decrease in overall average BMI values. Importantly, both the Klakk et al two-year study and this five-year study found that children who took part in the intervention benefitted from a decreased risk of overweight or obesity (7).

Other studies conducted by Lazaar et al (4), Sollerhed and Ejlertsson (5) and Kriemler et al (6) observed a larger decrease in BMI in intervention groups than control groups in studies that lasted for a shorter period and provided fewer extra physical education classes. Conversely, other comparable interventions conducted by Thivel et al (8) and Bugge et al (9) were not effective in reducing BMI and waist circumference. The contradictory findings of those studies could be due to several factors. We believe that population-based interventions that target obesity are more likely to have an impact on participants who are at risk of overweight and obesity. It is possible that conducting the same intervention in a country with a higher prevalence of overweight and obesity could have stronger effects on the mean BMI levels of the population. Moreover, weight loss is easier to achieve when nutritional restrictions are combined with an increase in energy expenditure (25), but the CHAMPS DK study only focused on increasing physical activity. If we had also focused on nutrition, it could have had a further visible effect on mean BMI and waist circumference and diminished the prevalence of children with overweight and the at-risk group with abdominal obesity (26). Other studies showed lower odds of becoming overweight or obese when individual took part in multi-component interventions, involving physical activity, nutrition and, or, family members (14,27).

Strengths and limitations

This study had several strengths, including the fact that it was a long-term intervention with a large cohort and multiple assessments over time. In addition, all the children in the intervention schools received the extra physical education lessons regardless of their weight status. The researchers had no influence or control on the physical education lessons provided by the teachers, reflecting a real-life setting and this increased the external validity of the study (19).

The cut-off points used to define overweight and abdominal obesity were both based on well-validated studies that used data from the Netherlands (21,22). Data from another study showed similarities between Danish and Dutch populations with regard to the prevalence of overweight and obesity (28). Using more accurate measurements of overweight and obesity, like dual energy X-ray absorptiometry, could have provided greater detail on the long-term effects of the intervention. However the earlier two-year study on part of this cohort, by Klakk et al (7), did not find a clearer picture of changes in body composition when the authors used dual energy X-ray absorptiometry scans and compared them with BMI.

In our study, children were assessed during puberty, when changes may occur due to changes in growth and body composition, as well as metabolic adaptations as a result of training (29). Thus, it is possible that the different results observed with regard to mean BMI and waist circumference might have been partly related to the maturational process during puberty. Nevertheless, it is reasonable to believe that the changes in weight status were due to the intervention, as we adjusted for known confounders and the study used a controlled design. It should be highlighted that a higher proportion of boys tended to perceive themselves more physically matured compared to the girls, although this difference was not statistically significant. Rasmussen et al (30) observed that boys were more likely to overestimate their pubertal status compared to girls, suggesting physical examination for more reliable measures.

The CHAMPS DK study was not a randomised intervention, as it would have been impossible to randomise the participating schools to either group. The intervention schools volunteered to take part in the study, while the control schools were matched to the intervention schools based on the socioeconomic status of the school area and the school size. This may not have eliminated all risk of confounding and selection bias. Children and their parents were not informed of the change in curriculum in the schools until just before the start of a new school year. Thus, the parents of the children attending the intervention schools did not choose those schools because of the study and no children moved between the intervention and control schools during the study.

We noted that 101 children dropped out of the study and this could have been due to moving to schools in another area or because the parents or the children withdrew their consent. At the end of the study, the number of participants were 9% lower in the intervention group and 7% lower in the control group than at the start of the study in 2008. Finally, the children in the intervention schools received more physical education lessons, but the intensity and quality the lessons were not monitored.

CONCLUSION

The intervention helped to tackle overweight and obesity. We found that providing 4.5 hours of physical education lessons per week in primary schools, rather than the Danish standard of 1.5 hours, showed a favourable five-year effect on mean BMI values. It also decreased the risk of remaining overweight and abdominally obese at the end of the study period. This school-based intervention had a positive impact on undesirable weight gain in children and adolescents, especially those who risked long-term health issues because of their weight. One of the cornerstones for successfully maintaining the programme was that the extra physical education lessons were mandatory, leading to high adherence and compliance to the programme for both teachers and students. It also meant that overweight children were not stigmatised. The preventive effect of simply increasing the amount of physical education offered to younger children could have considerable potential in large-scale national programmes in most western countries. The potential could be even higher in countries with a higher prevalence of overweight and obesity. However, more experimental research is needed and it should focus on the most effective duration, dose and intensity of school-based physical education interventions.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

LIST OF ABBREVIATIONS

BMI Body mass index, BMI-SDS, Body mass index standard deviation score.

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Table 1. Baseline values for the key variables by school type and gender, based on 1,178 of the 1,299 children who took part in the study

	Six intervention schools			**Four control schools**		
	Girls n=372 (55.03%)	Boys n=304 (44.97%)	Total n=676	Girls n=255 (50.27%)	Boys n=247 (49.73%)	Total n=502
Key variables: mean (SD)						
Age (years)	8.34 (1.41)	8.42 (1.40)	8.37 (1.41)	8.41 (1.48)	8.51 (1.47)	8.46 (1.47)
Height (cm)	131.56 (9.49)	133.63 (9.74)	132.49 (9.65)	131.86 (9.98)	133.59 (10.30)	132.71 (10.16)
Weight (kg)	28.85 (6.61)	29.42 (6.88)	29.11 (6.73)	29.37 (7.62)	29.73 (6.76)	29.55 (7.20)
BMI (kg/m^2)	16.47 (2.15)	16.25 (2.10)	16.37 (2.13)	16.65 (2.39)	16.46 (1.84)	16.56 (2.13)
BMI-SDS	0.122 (1.034)	-0.069 (1.072)	0.036 (1.055)	0.177 (1.112)	0.974 (1.055)	0.138(1.084)
WC (cm)	57.95 (6.77)	58.26 (6.73)	58.09 (6.75)	58.94 (7.50)	59.04 (6.02)	58.99 (6.80)
Birthweight (kg)	3.42 (0.67)	3.58 (0.68)	3.49 (0.68)	3.52 (0.63)	3.58 (0.59)	3.55 (0.61)
Prevalence (%)						
Overweight (BMI)	14.78%	8.58%	12.00%	15.29%	10.53%	12.95%
Abdominal obesity (WC)*	16.71%	12.17%	14.66%	22.75%	14.57%	18.73%
Tanner stages 4 and 5	13.62%	25.57%	18.99%	10.43%	26.54%	18.44%

*: Significant difference in girls and total population by school type ($p \leq 0.005$)

Overweight defined according to International Obesity Task Force criteria in Cole et al (21)

Abdominal obesity defined by Fredriks et al (22) cut-off points

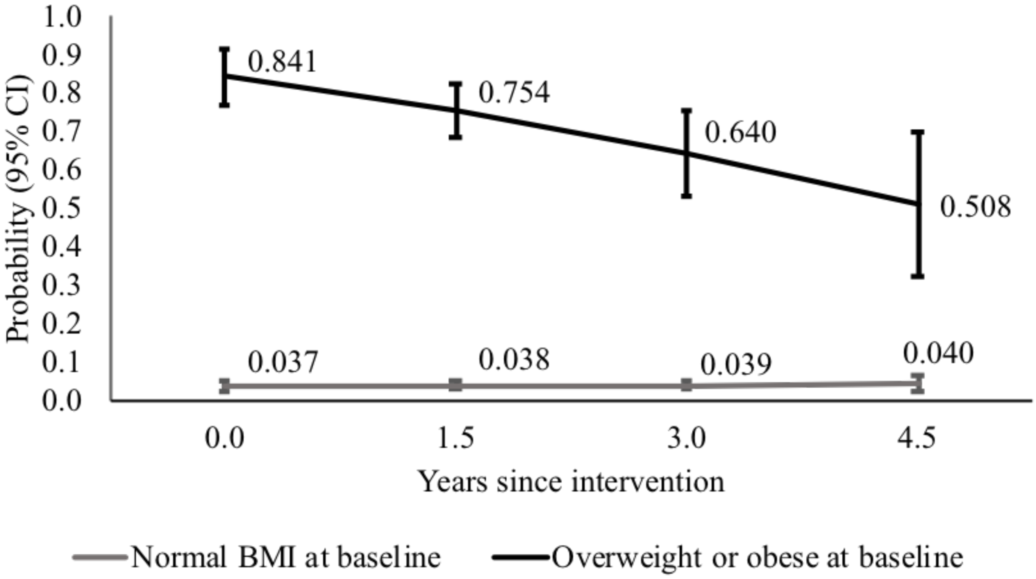

Figure 1. Predicted probability of being overweight or obese by baseline category for each additional year exposed to the intervention Adjusted for BMI at baseline, sex, pubertal stage, age and mothers' educational level (n=836) p< 0.001).

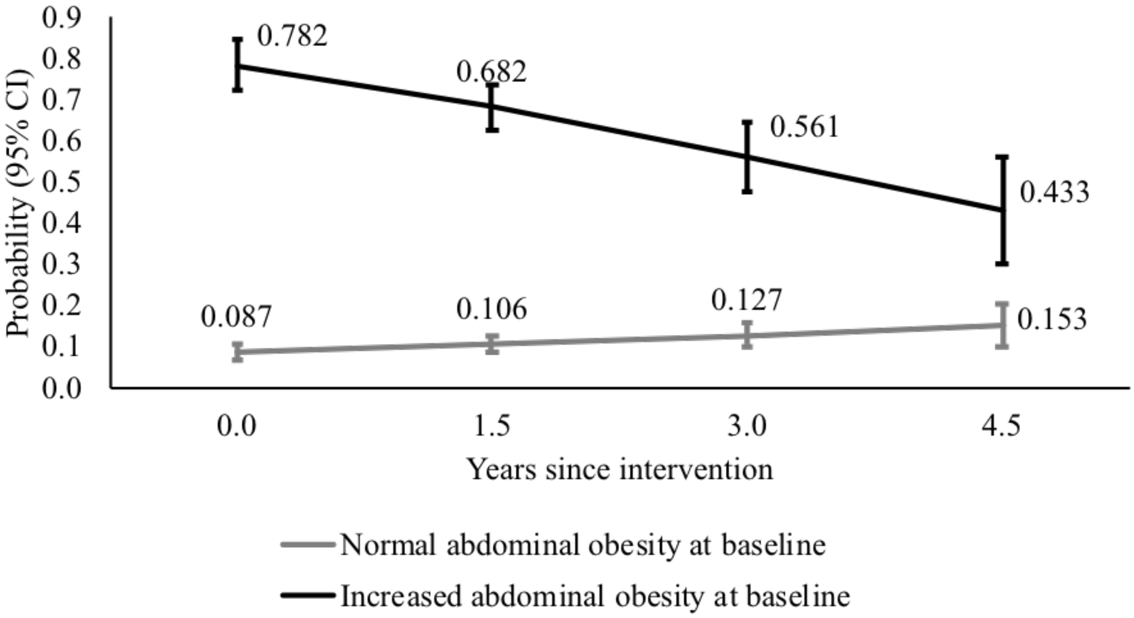

Figure 2. Predicted probability of having increased abdominal obesity by baseline category for each additional year exposed to the intervention. Adjusted for waist circumference at baseline, sex, pubertal stage, age and mothers' educational level (n=837) ($p < 0.001$).