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PART II. PHYSICAL ACTIVITY OF SOCIAL AND PROFESSIONAL GROUPS
DZIAŁ II. AKTYWNOŚĆ FIZYCZNA GRUP SPOŁECZNYCH I ZAWODOWYCH

USING ACCELEROMETERS AS A METHOD FOR IMPROVING COMPLIANCE WITH PHYSICAL ACTIVITY RECOMMENDATIONS IN THE TREATMENT OF OBESITY IN CHILDREN

WYKORZYSTANIE AKCELEROMETRÓW JAKO METODY POPRAWY PRZESTRZEGANIA ZALECEŃ DOTYCZĄCYCH AKTYWNOŚCI FIZYCZNEJ W LECZENIU OTYŁOŚCI U DZIECI

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C. Data analysis/statistics
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D. Data interpretation
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E. Preparation of manuscript
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Summary

Background. The evidence has showed that increasing physical activity is a particularly important element not only in prevention but also in the treatment of obesity. This study aimed to examine whether the use of accelerometers for monitoring physical activity is a sufficient motivator to adhere the recommended level of physical activity.
Material and methods. The prospective study involved 44 obese children and adolescents aged 5 to 17 who were registered with the Pediatric Nephrology Department at the Medical University of Bialystok, Poland. Participants had to wear a device for at least 12 hours per day for 56 consecutive days. Anthropometric measurements were made at the beginning of the study and after eight weeks of physical activity monitoring.
Results. The presented study results far exceeded the recommended amount of the average physical activity energy expenditure of young patients in the first two weeks. In the following weeks, the amount of daily energy expenditure gradually diminished, but finally, the average BMI Z-score was reduced from 2.80±0.64 at baseline to 2.48±0.27 at the end of the study (p<0.0147).
Conclusions. The study demonstrates that tracking of physical activity may be an essential factor to improve compliance with physical activity recommendations.

Keywords: obesity management, physical activity, health behavior, physical therapy, compliance

Streszczenie

Wprowadzenie. Wyniki badań wykazują, że zwiększenie aktywności fizycznej jest szczególnie ważnym elementem nie tylko profilaktyki, ale także leczenia otyłości. Niniejsze badanie miało na celu stwierdzenie, czy wykorzystanie akcelerometrów do monitorowania aktywności fizycznej stanowi wystarczający czynnik motywujący do przestrzegania zalecanego poziomu aktywności fizycznej.
Materiał i metody. W prospektywnym badaniu wzięło udział 44 otyłych dzieci i nastolatków w wieku od 5 do 17 lat, którzy zostali zarejestrowani w Klinice Pediatrii i Nefrologii Uniwersytetu Medycznego w Białymstoku. Uczestnicy musieli nosić urządzenie przez co najmniej 12 godzin dziennie przez 56 kolejnych dni. Pomiary antropometryczne wykonano na początku badania i po ośmiu tygodniach monitorowania aktywności fizycznej.
Wyniki. Wyniki badania wykazały znaczne przekroczenie zalecanej ilości średniego wydatku energetycznego związanego z aktywnością fizyczną młodych pacjentów w ciągu pierwszych dwóch tygodni. W kolejnych tygodniach ilość dziennego wydatku energetycznego stopniowo malała, ale ostatecznie średni Z-score BMI został zmniejszony z 2,80±0,64 na początku badania do 2,48±0,27 na końcu badania (p< 0,0147).
Wnioski. Badanie pokazuje, że monitorowanie aktywności fizycznej może być istotnym czynnikiem poprawiającym przestrzeganie zaleceń dotyczących aktywności fizycznej.

Słowa kluczowe: leczenie otyłości, aktywność fizyczna, zachowania zdrowotne, fizykoterapia, przestrzeganie zaleceń

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Introduction

Obesity in children and adolescents is a global problem associated with high morbidity and mortality, as well as psychological distress. The causes of this non-communicable chronic disease are very complex and multifaceted and need multidimensional programs of treatment involving changes in behavioral habits concerning both nutrition and physical activity. The evidence showed that increasing physical activity is a particularly important element not only in prevention but also in the treatment of overweight and obesity [1]. With the global prevalence of obesity among children and adolescents, there is an urgent need for not only effective prevention but also treatment programs that involve increasing physical activity.

The proportion of children with excess body fat and the age at which obesity occurs is rapidly decreasing. In the European Union countries, as many as 20% of children and adolescents have excess body weight. This equates to over 12 million children being either overweight or obese [2]. The trend is especially noticeable among the young citizens of new European Union member countries, including Poland. In the Polish population, the incidence of childhood obesity is extremely high, especially in girls [3].

The spread of obesity in children is a serious health concern because it is associated with increased risk for many chronic diseases in childhood. It also predisposes children to the development of morbidity as adults. The scientific evidence shows that increased body mass index in children correlates with atherosclerosis, type 2 diabetes, and other chronic, non-communicable diseases in adulthood [4].

In the last decades, the main causes of insufficient physical activity among children and adolescents have related to changes in lifestyle. This is especially true of the ways in which young people now spend their leisure time, and of how they commute to and from school. There is a strong body of evidence showing the importance of regular physical activity as an effective method for preventing and treating cardiovascular and other non-communicable diseases. Physical activity, when carried out with adequate frequency, intensity, and duration, offers many positive clinical benefits [5,6]. In the prevention and treatment of obesity, children and adolescents' physical activity plays a fundamental role [7]. The implementation of behavioral changes leading to increased physical activity in all domains of everyday life is, on that account, a key element of prescription for the treatment of child obesity [8].

Our knowledge about human motivation and health behavior change indicates that we should take advantage of the proven efficacy of pediatric obesity prevention and treatment. The compliance of patients, especially in increasing everyday physical activity or decreasing sedentary behavior, is the fundamental problem in this field. Recent recommendations for children indicate the need to engage in daily, either planned or unplanned, physical activity from moderate to vigorous intensity (MVPA) for a minimum of 60 minutes per day [9]. Currently, only 17 per cent of Polish adolescents meet the World Health Organization's recommendations for moderate physical activity. Comparing data from two rounds of the HBSC survey (2018 vs. 2014), the percentage of adolescents meeting WHO recommendations in this regard decreased by 7 percentage points – from 24.2 to 17.2 per cent [10,11].

Until the first decade of the 21st century, the most common methods of measuring physical activity in children and adolescents were self-reporting or parent-completed diaries or standardized questionnaires. While they provided useful information about physical activity, their diagnostic value, especially for individual and small group measurements, was limited and subject to large errors [12,13]. For this reason, there has been increasing use of objective methods, particularly accelerometers, to assess physical activity in children and adolescents. Several reviews have found that accelerometers provide an accurate, reliable and practical objective measure of physical activity in children and adolescents.

The use of these devices to measure physical activity began with the advent of accelerometers in the early 2000s, which can objectively measure any movement of the body. In particular, innovative measurement

methods and tools have been used to assess physical activity in children and adolescents. Several reviews have found that accelerometers provide an accurate, reliable and practical objective measure of physical activity in children and adolescents [14,15].

Nowadays, various specifications of mobile devices for measuring physical activity are becoming increasingly available in the market, and their usage can help in the treatment of obesity. Continuous monitoring of physical activity is currently the only way to reliably measure the activity of the population as a whole, as well as that of individual patients with obesity or other diseases. It is very important for surveillance and especially for assessing the effectiveness of interventions or public health initiatives aimed at increasing physical activity and treating obesity in individuals. An accelerometer's data collected in real time can show patterns of activity, and there are good relationships between counts per minute (CPM) and physical activity energy expenditure (PAEE) [16].

The aim of this study was to examine whether the use of accelerometers for monitoring physical activity interlaced periodic medical appointments is a sufficient motivator for children and their families to adhere to the recommended level of physical activity. We also sought to determine whether using accelerometers has any value in the treatment of obesity in children and adolescents.

Material and methods

The prospective study involved 44 obese children and adolescents (29 girls and 15 boys) aged 5 to 17 (Mean=10.5, SD=3.5) who were registered as patients with the Pediatric Nephrology Department at the Medical University of Bialystok in Poland (Table 1). The sole inclusion criteria were obesity as assessed by reference determined by Kulaga et al. [3], and the consent of the participants and their parents.

Table 1. Demographic characteristics of the participants in the study

Sample size	**Total**	**n=44**
	Girls	65% (n=29)
	Boys	35% (n=15)
Age [in years]	**Mean (SD)**	10.4 (3.5)
	Median (IQR)	10.1 (7.5-12.7)
	Range	5-17

The monitoring of daily physical activity was guided for eight consecutive weeks (56 days), and was performed with the use of GT3X+ ActiGraph accelerometers. At the end of the fourth and eighth weeks, participants and their parents came to medical appointments for additional motivation and to have the data from the accelerometers read. Detailed discussions of the physical activity recorded as accelerometer data during the medical appointments were used as additional motivation for participants to comply with physical activity recommendations. The participants of the study and their parents were informed about the recommended level of physical activity, adjusted for sex, age, and the degree of overweight [9,17]. During first medical appointment, each participant was equipped with an accelerometer, and children and their parents were given instructions for using the device. We instructed them to wear the monitor just above the right hipbone, underneath or on top of clothing, using an elastic belt, for a minimum of 12 hours per day. The guidelines for when and how to wear the device were designed to meet the criteria for *wearing* and *non-wearing* days in accordance with generally accepted recommendations [18,19].

Anthropometric measurements were made at the beginning of the study and after 8 weeks of physical activity monitoring. Body weight and height were measured using a balance beam scale and pediatric wall-mounted stadiometer, and body mass index (BMI) was calculated as weight (kg) divided by the square of

height (m^2). Age- and gender-specific reference values for BMI were generated using the LMS method [20] which characterizes the distribution of a variable by its median (M), the coefficient of variation (S, i.e., the ratio of the SD and mean), and skewness (L) required to transform the data to normality. The evaluation of these parameters is obtained by maximum-likelihood curve-fitting algorithm to the original data plotted over the independent variable. The formula for calculating Z-score of BMI or height was LMS – SDS={[Y/M(t)]L(t)-1}/[L(t) x S(t)], where Y is the individual observation, and L(t), M(t), and S(t) are the specific values of L, M, and S interpolated for the child's age and gender. The LMS values were taken from WHO growth reference for school-aged children and adolescents published by De Onis et al. [21].

The analysis of the data was performed with ActiLife 6.0 and Statistica 10.0. Physical activity levels were assessed using computed daily energy expenditure and EE spent in moderate to vigorous physical activity (MVPA). The results received from accelerometers on the daily step count were compared to the level recommended by Adams et al. and Tudor-Locke et al. [22,23]. All variables were expressed as median with the interquartile range (Q1-Q3). The comparisons between physical activity levels for each consecutive week in particular categories were made with the chi-square and multivariate analysis ANOVA (Kruskal-Wallis). Statistical significance was set at $p<0.05$.

The Bioethics Committee of the Medical University of Bialystok in accordance with the Declaration of Helsinki approved the protocol.

Results

The average physical activity energy expenditure (PAEE) of children measured in kcal every day of the first two weeks of study far exceeded the recommended amount. In the following weeks of the study, the daily PAEE gradually decreased, but remained at a level that exceeded the recommended value. The average daily PAEE during the first week amounted to 373.00 kcal, whereas during the last week of the study (eighth week), it was as low as 194.70 kcal ($p<0.001$). A similar relationship, but not as strong, was observed during moderately to vigorously intense physical activity. The average daily MVPA energy expenditure during the first week amounted to 174 kcal, whereas during the last week of the study, it was 121 kcal ($p<0.0215$). The average step counts per day measured by accelerometers every week of study were below the recommended level and decreased gradually from 9.017 steps/day during the second week to 4.826 steps/day during the last week ($p<0.001$) (Table 2).

Table 2. Correlations between the levels of average total daily physical activity, recommended level of intensity and steps counts

Week	Daily PAEE*	Daily MVPAEE**	Daily Steps Counts
first week	373.00 (223.00-559.60)	174.00	8440.00
second week	404.35 (255.10-619.80)	179.50	9017.00
third week	296.70 (143.90-486.70)	156.42	7624.00
fourth week	338.05 (222.20-478.10)	163.33	7749.50
fifth week	269.20 (91.50-503.10)	145.25	7787.50
sixth week	288.80 (167.90-464.70)	162.50	7496.00
seventh week	235.50 (91.40-408.90)	144.33	6313.00
eighth week	194.70 (76.40-320.10)	121.17	4826.00
p-value	<0.001	<0.0215	<0.001

Notes: * – PAEE (Physical Activity Energy Expenditure), ** – MVPA EE (Moderate to Vigorous Physical Activity Energy Expenditure).

We did not know the daily PAEE of the study participants before the intervention. Nevertheless, the average BMI Z-score was reduced from 2.80±0.64 at baseline to 2.48±0.27 at the end of the study (p<0.0147) (Figure 1).

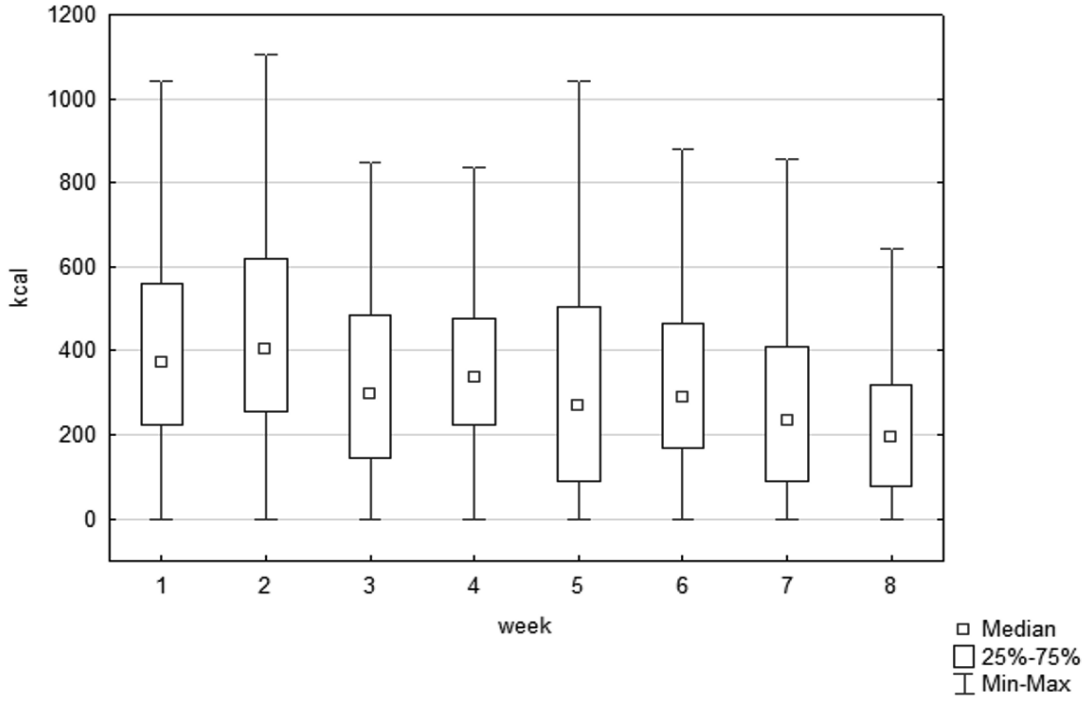

Figure 1. Daily PAEE of the study participants in each consecutive week

Discussion

Although obesity is a complex phenomenon involving many factors, its basic cause is an imbalance between energy intake and energy expenditure. Physical activity is the main modifiable component of the total energy expenditure, and it plays a fundamental role in one's daily energy balance: increasing physical activity can improve weight loss.

The basic problem with the inclusion of increased physical effort in the treatment of obesity is the patient's compliance. Electronic monitors of physical activity, like pedometers and accelerometers, which are increasingly becoming common, may be effective in increasing patient compliance. The basic criterion for the inclusion of these devices into obesity therapy programs is providing monitors with high utility parameters. We know that devices should fulfil some basic conditions that may encourage children to wear them and that will reliably record physical activity data [24].

Another method of obtaining a high level of compliance is the use of various types of motivators to encourage patients to wear the device and, on the other side, increase the time and intensity of physical activity. Due to the simplicity and low cost, text messages are the most frequently used [25]. This type of motivation may significantly improve minutes of wear time, but it is not effective enough in increasing daily and weekly physical activity levels [26]. In light of the results of some research, the awareness of being monitored may play a fundamental role in changing habitual physical activity behavior [27].

Therefore, in the present study, we used medical appointments as part of the evaluation program to motivate the patients and their parents. Motivational strategies are essential for success in treating obesity. The authors of the review study on this problems [28] state that the most promising results can be obtained among children and adolescents by using motivationally tailored strategies and programs for primary care settings.

It seems that the inclusion of physical activity with controlled compliance using accelerometers may bring desirable results. According to Zizzi et al. [29], 70% of the participants in their study reported that using pedometers positively impacted their awareness or motivation towards physical activity. The results of a systematic review by Bravata et al. [30] show that the use of pedometers among the adult population is associated with significant increases in physical activity and significant decreases in body mass index. The findings obtained in the present study are similar and confirm the positive impact of a pedometer/accelerometer, regardless of the age of the users. Nevertheless, the strength of the impact decreased by nearly half, comparing PAEE during the first week and the last week. Noteworthy results regarding PAEE were observed in the fourth week leading up evaluation and reading data. It indicates improved compliance of patients before their medical appointment, and this could be the basis for holding such meetings as often as possible.

Raising the level of physical activity in children and adolescents is one of the primary goals in the early prevention of chronic non-communicable diseases. Current WHO recommendations in this regard, however, are focused on increasing the amount of MVPA to a minimum of 60 minutes per day of physical effort with an intensity not less than 3METs. In our study, the average daily MVPA EE accounts for 47% of the daily general physical activity during the first week and 62% of the daily general physical activity during the last week of the study. The daily general physical activity level decreased gradually from the second week, but the amount of MVPA gradually increased. It might be the result of the reduction each week of the amount of physical activity in the household and active transportation domains. Nevertheless, the results confirm that any amount of physical activity, even small, can help treat obesity in children. This is probably because, as some studies have shown, low-intensity activities, such as walking to school or playing active games, can be a decent and more feasible substitute for sitting [31].

The reduction of the energy expenditure associated with physical efforts each week of the study was also associated with a statistically significant decrease in the average daily step counts performed by the study participants. During the first and second week, the average amount of step counts per day made by participants was sufficiently close to the level recommended by Adams et al. [22] (8440 and 9017 respectively) but significantly below the recommendation of Tudor-Locke et al. [23], even for pre-school children. Every successive week, the number of step counts decreased drastically, and in the last week (eighth week), the number of steps was 4826 per day – about 43% less than that in the first week (p<0.001). However, according to Olds et al. [32] who calculated that 1 minute of MVPA=103 steps, we can conclude that the activity level of the children in our study met the minimum recommendations, and only in the last week was it around 47 minutes of MVPA – 78% of the recommended time. However, we believe that this drastic reduction in the number of steps taken per day may indicate a reluctance on the part of today's young people to engage in active transportation. This may indicate a need for further motivational interventions or a search for other reasons for the decline in activity.

Conclusions

The results of numerous studies confirm that the effective treatment of obesity and its complications cannot be conducted without the implementation of behavioral therapy and changes in the daily habits associated with physical activity. Prescription for physical activity, frequency, intensity, time, and type of effort and then monitoring and evaluating compliance may be an effective method for obtaining a negative energy balance and leading to weight loss. Participants of the presented statistical study significantly reduced their BMI, which is strong evidence for the effectiveness of this intervention.

Limitations

A small research group, short observation period and the lack of adequate comparative material did not allow us to draw far-reaching conclusions. This preliminary research may only serve as a base for future studies.

Disclosures and acknowledgments

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