Introduction

Overweight and obesity are defined as “abnormal or excessive fat accumulation that poses a risk to health” [1]. Childhood obesity, like adults, is one of the important public health problems of the 21st century that needs to be tackled [2]. It is estimated that the prevalence of obesity in children and adolescents worldwide is constantly increasing and that 91 million children will be obese in 2025 [3].

Childhood obesity is associated with many life-threatening diseases such as cardiovascular diseases [4], cancer [5], liver diseases, diabetes [6]. Additionally, obesity creates emotional and psychological problems in children [7] and causes them to have many negative social experiences [8]. Moreover, childhood obesity causes children to step into adulthood with many health problems and social exclusion caused by obesity [9, 10]. Being overweight or obese under the age of 18 is associated with an increased risk of early death after middle adulthood [11].

Multiple etiological factors cause obesity, which should be considered a life-long disease. These factors include prenatal causes (such as genetics, maternal diabetes, maternal smoking, maternal hypercholesterolemia), neonatal/infancy-related causes (such as birth weight > 4 kg, formula feeding or short-term breastfeeding < 4 months), and child/adolescence period. It can be examined under three main headings (low education level, parental obesity, insufficient physical activity, diet) [12].

One of the important etiological factors for childhood obesity is physical inactivity. Therefore, strategies to prevent physical inactivity have an important place in both the pre-
vention and treatment of obesity in children [13]. School-based physical activity programs are effective in reducing waist circumference and body mass index [14]. However, the relationship between sports participation and obesity in children is unclear [15]. While some studies claim that participation in team sports will positively affect weight control [15], some studies report that the relationship between sports participation and BMI is weak [16]. A multidisciplinary approach that includes interventions such as physical activity, diet, etc., improves health-related physical fitness parameters [17]. In the literature, few studies showing that obese children’s participation in sports has positive effects on muscle strength, muscular endurance, cardiovascular fitness and balance [18, 19]. However, researches that will examine the effects of especially overweight and obese children’s participation in sports on obesity indicators and health-related physical fitness parameters are needed.

This study aimed to examine the effects of sports participation on body mass index (BMI), waist circumference, hip circumference, muscle strength, muscular endurance, balance and agility in obese boys.

Materials and methods
Sixty three male obese children with a mean age of 10.80 ± 0.58 years were included in the study. Inclusion criteria for the study; volunteering, BMI above the 95th percentile, not maintaining a regular physical activity program, not having a cardiovascular disease that would prevent participation in sports, not having a respiratory system disease that would prevent participation in sports, not having an orthopedic disability that would prevent participation in sports. The data of the participants who did not attend 3 consecutive sports sessions for any reason and who completed the tests for any reason were excluded from the study. Informed consent was obtained from the participants and their relatives or caregivers before starting the study.

Obese students were determined among the 4th grade students of the schools. Obesity was decided according to body mass index (BMI). The weight and height of the children were measured. BMI was calculated according to the formula BMI = kg/m². Those with BMI percentile above the 95th percentile of the age- and sex-specific BMI percentile curve were invited to participate in the study.

Those included in the study were examined and it was questioned whether they had any diseases that would prevent participation in the study by a sport physician. Body weight, height, waist circumference and hip circumference were measured before and after participation in sports. Grip strength, bent arm hanging, one-leg balance and plate tapping tests were applied to the participants before and after participating in the sport. Testing was done bilaterally and by the same testers. Three measurements were made for each test and averaged. Jamar hand dynamometer, which is accepted as the gold standard, was used to measure the grip strength. To measure muscular endurance of the upper extremity muscles, the timed bent-arm pull-up hang test was performed. The single-leg balance test against time was used to determine the postural balance. Plate tapping test was performed to measure upper extremity movement speed and reaction time.

Participants were allowed to participate in basketball, judo and table tennis sports three days a week for 3 months. Sports activities were performed with the facilities of the school during the hours outside the school hours of the children. The sports activity included a 10-minute warm-up session consisting of jogging, stretching exercises, and mobility exercises, a 30-minute main section containing sport-specific skills and games, and a 10-minute cool-down period consisting of stretching exercises.

IBM SPSS 21.0 (IBM Corp. Armonk, NY, USA) was used for statistical analysis of the data. Mean ± standard deviation and median (minimum and maximum values) values of continuous variables were calculated. The Shapiro-Wilk test was used to determine the conformity of the data to the normal distribution. The participant pre-participation in sports (PRESP) and post-participation in sports (POSTSP) measurement results was compared. Student’s t-test was used to compare the variables with a normal distribution. Wilcoxon signed-rank test was used to compare the variables that did not fit the normal distribution. P < 0.05 was considered significant.

Results
While PRESP weight, height and BMI values of the participants were 50.79 ± 7.99 kg, 1.48 ± 0.05 m and 23.04 ± 2.89 kg/m² respectively, POSTSP weight, height, and BMI values were 50.59 ± 7.93 kg, 1.49 ± 0.05 m and 22.51 ± 2.88 kg/m². POSTSP BMI measurement results were less than PRESP measurement results (p < 0.01, Table 1). POSTSP waist and hip circumference measure-

### Table 1. Obesity indicators of the participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>PRESP MO</th>
<th>POSTSP MO</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>50.79 ± 7.99</td>
<td>50.59 ± 7.93</td>
<td>0.314</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.48 ± 0.05</td>
<td>1.49 ± 0.05</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.04 ± 2.89</td>
<td>22.51 ± 2.88</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>81.61 ± 8.56</td>
<td>79.38 ± 8.74</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>87.69 ± 6.52</td>
<td>85.73 ± 6.65</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Waist/Hip ratio</td>
<td>0.92 ± 0.04</td>
<td>0.92 ± 0.04</td>
<td>0.108</td>
</tr>
</tbody>
</table>

Notes: PRESP MO — pre-participation in sport measurement outcomes; POSTSP MO — post-participation in sport measurement outcomes; * — comparison of pre-participation and post-participation value with Student t test; * — p < 0.05.
ment results of the participants were decreased compared to PRESP results (p < 0.01, table 1). On the other hand, POSTSP waist-hip ratio was not different from PRESP (p = 0.108, table 1).

The POSTSP results of the one-leg balance and bent-arm hanging tests were higher than the PRESP results (p < 0.01, table 2). However, the POSTSP results of the plate tapping test were less than the PRESP results (p < 0.01, table 3). The result of POSTSP grip strength test was not different from the result of the PRESP grip strength test (p > 0.05, table 3).

**Discussion**

This study aimed to investigate the changes in some obesity indicators and health-related physical fitness parameters in obese children who participated in sports with their peers in similar situations in school settings. Study results; showed that BMI, waist circumference and hip circumference can be reduced with the participation of obese children in sports. Additionally, participation in sports in obese children is effective in improving muscular endurance, agility and balance.

Obesity is a preventable and treatable non-communicable disease. Risk factor analysis and implementation of protective actions, especially physical activity, in school-age children are effective in reducing childhood obesity [19]. In overweight and obese children; Strength exercises combined with aerobics and aerobics improve measurement results related to adiposity. In this context, exercise programs containing related components reduce BMI, fat percentage and central adiposity [20]. It has been reported that methods to increase physical activity, such as multi-component school physical activity programs and school-gardening projects, have positive effects on anthropometric measurements such as BMI and waist circumference, and on children's health in general [13, 21]. However, the effects of sports participation on obesity indicators in overweight and obese children are not yet clear enough. Cairney et al. reported that despite the many health and social benefits of participation in sports, effects of BMI and BMI on participation in sports are limited [16]. Clark et al. reported that sports participation has important effects on the health and development of the child, but participation in organized sports don’t provide much benefit in terms of weight control in children and adolescents [22]. In contrast, Drake et al., stated that there is a strong and inverse relationship between participation in team sports and weight status compared to other methods to increase physical activity. Researchers emphasized that the prevalence of obesity decreased by 26 % in individuals who played at least on a sports team per year [16]. Sirard et al. reported that participation in team sports had a positive effect on BMI in girls [23]. According to the results of this study, the weight and waist-hip ratio of the participants did not change, hip circumference, waist circumference decreased, and BMI decreased. The lack of change in weight can be attributed to the increase in lean body mass. The lack of difference in waist-hip ratio can explained by the similar decrease in waist and hip circumferences. The positive change in obesity indicators seen in the results of the study; it can be associated with the positive effects of participation in sports and school-based physical activity programs on obesity and supports this information [13, 15, 21, 23].

Multicomponent exercise programs improve physical fitness in overweight and obese children regardless of exercise frequency [24]. Bogataj et al. reported that high-intensity intermittent exercise increased muscle strength and aerobic performance in girls [25]. Molina-Garcia et al. reported that a 13-week exercise program based on movement quality and multiple games increased children’s general muscle strength, jump performance, and functional movement skills [26]. It has been reported that aerobic game

**Table 1. Balance and muscular endurance results of the participants**

<table>
<thead>
<tr>
<th>Variable</th>
<th>PRESP MO</th>
<th>POSTSP MO</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x±SD</td>
<td>Median (IQR)</td>
<td>x±SD</td>
</tr>
<tr>
<td>Right Single Leg Stance Test (sec)</td>
<td>40.21 ± 2.21</td>
<td>38.00 sn IQR: 34.00</td>
<td>49.19 ± 2.00</td>
</tr>
<tr>
<td>Left Single Leg Stance Test (sec)</td>
<td>40.22 ± 2.46</td>
<td>44.00 sn IQR: 35</td>
<td>49.29 ± 2.00</td>
</tr>
<tr>
<td>Flexed Arm Hanging Test (sec)</td>
<td>2.46 ± 0.72</td>
<td>0.00 sn IQR: 2.83</td>
<td>3.71 ± 0.72</td>
</tr>
</tbody>
</table>

**Notes:** PRESP MO — pre-participation in sport measurement outcomes; POSTSP MO — post-participation in sport measurement outcomes; * — Wilcoxon signed rank test; * — p < 0.05.

**Table 2. Results of participants’ grip strength and plate tapping tests**

<table>
<thead>
<tr>
<th>Variable</th>
<th>PRESP MO</th>
<th>POSTSP MO</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x±SD</td>
<td>Median (IQR)</td>
<td>x±SD</td>
</tr>
<tr>
<td>Right Hand Grip Strength (kg)</td>
<td>18.37 ± 4.70</td>
<td>19.15 ± 3.94</td>
<td>0.095</td>
</tr>
<tr>
<td>Left Hand Grip Strength (kg)</td>
<td>17.66 ± 4.46</td>
<td>17.77 ± 3.86</td>
<td>0.805</td>
</tr>
<tr>
<td>Right Plate Tapping Test (sn)</td>
<td>14.69 ± 1.85</td>
<td>12.92 ± 1.48</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Left Plate Tapping Test (sn)</td>
<td>16.35 ± 1.79</td>
<td>14.24 ± 1.57</td>
<td>&lt; 0.01*</td>
</tr>
</tbody>
</table>

**Notes:** PRESP MO — pre-participation in sport measurement outcomes; POSTSP MO — post-participation in sport measurement outcomes; * — Student t test; * — p < 0.05.
programs at school improve aerobic endurance, muscle strength, jump performance, speed and balance [27]. It has been reported that aerobic and resistance muscle strengthening program including soccer, basketball, volleyball and rugby drills increase cardiovascular endurance and muscle strength in obese children [28]. In this study, basketball, table tennis and judo sports improved muscular endurance, balance and agility in obese children, but did not affect grip strength. Along with physical activity, diet and psychosocial factors also affect physical fitness parameters. Therefore, failure to standardize diet and psychosocial factors may have limited the improvement in physical fitness measured in the study [29]. Additionally, the fact that only grip strength was measured may not reflect the possible increase in muscle strength. Generally, the results of the study show that structural and group exercise based on a sport branch have positive effects on physical fitness parameters and support the literature on this subject.

Increasing the level of physical activity plays an important role in reducing obesity or stopping its progression in obese children [19]. Participation in sports is an important tool for increasing the level of physical activity [15, 23]. However, different exercise barriers that prevent obese children from participating in sports, such as transportation difficulties, lack of time, lack of information, and lack of appropriate environment [30]. It is possible to fight obesity with recreational sports organizations that are planned to minimize exercise barriers [20]. Additionally, considering the factors that will facilitate participation in exercise, such as peer support, the supervision of a trainer or teacher, in recreational sports organizations will maximize participation in sports and thus the benefits of participation in sports [30]. Considering exercise barriers and factors facilitating exercise contributed to the improvement in obesity indicators and health-related physical fitness parameters in this study.

This study has some limitations. No control group has been established to give every child an opportunity. It has prevented the effects of sports participation on obesity indicators and health-related physical fitness parameters from being seen obviously.

Conclusions

As a conclusion, when obese children are given the opportunity to participate in sports in their social environment, improvement in obesity indicators and improvement in health-related physical fitness parameters will be achieved. For this reason, supervised exercise programs should be designed that minimize the factors that prevent obese children from participating in sports, are structured to reflect the content of different sports branches, and can be performed with their peers in the school environment.

References


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Вплив занять спортом у хлопчиків з ожирінням на деякі показники ожиріння і параметри фізичної підготовки

Резюме. Актуальність. Вивчення впливу занять спортом у хлопчиків з ожирінням на індекс маси тіла (ИМТ), окружність талії, окружність стегон, м’язову силу, м’язову втривальність, рівновагу і спритність. Матеріали та методи. У дослідженні були включено шістдесят три хлопці з ожирінням, середній вік яких становив 10,80 ± 0,58 року. Учасники протягом трьох місяців займались спортом, у тому числі дзюдо, на стільник теніс і баскетбол, у своїх школах. Маса тіла, окружність талії та окружність стегон учасників вимірювалася до і після занять спортом. До і після участі у спортивних змаганнях учасники проходили тести на силу захвату, підвішування на зігнутій руці. Результати. До занять спортом показники IMT, окружність талії та стегон в учасників були 23,04 ± 2,89 см/м², 81,61 ± 8,56 см і 87,69 ± 6,52 см відповідно; після занять спортом показники IMT, окружність талії та стегон становили 22,51 ± 2,89 см/м², 79,38 ± 8,74 см і 85,73 ± 6,65 см відповідно. Результати тестів на рівновагу на одній нозі і підвішування на зігнутій руці після занять спортом покращились порівняно з показниками, отриманими до занять спортом (р < 0,05). Однак результуючи тесту на постукування по пластині, рівновагу в стійці на одній нозі й постукування по пластині. Результати. До занять спортом показники IMT, окружність талії та стегон в учасників були 23,04 ± 2,89 см/м², 81,61 ± 8,56 см і 87,69 ± 6,52 см відповідно; після занять спортом показники IMT, окружність талії та стегон становили 22,51 ± 2,89 см/м², 79,38 ± 8,74 см і 85,73 ± 6,65 см відповідно. Результати тестів на рівновагу на одній нозі й підвішування на зігнутій руці після занять спортом покращились порівняно з показниками, отриманими до занять спортом (р < 0,05). Однак результуючи тесту на постукування по пластині, рівновагу в стійці на одній нозі й постукування по пластині. Висновки. Регулярні занять спортом у дітей з ожирінням позитивно впливають на IMT, окружність талії та окружність стегон, які пов’язані з хронічними захворюваннями. Крім того, регулярні заняття спортом у дітей з ожирінням сприяють покращенню параметрів фізичної підготовленості, які є показниками здоров’я.

Ключові слова: дитинство; ожиріння; фізичні вправи

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