



The algorithm for overload syndrome prevention: Osgood-Schlatter's syndrome as an overload syndrome caused by early inclusion of children in sports and excessive physical activity (sports and recreation)

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ABSTRACT

Introduction: Osgood-Schlatter's syndrome (Osgood-Schlatter disease [OSD]) is caused by an accumulation of repeated microtraumas and is classified as a type of chronic injury called "overload syndrome". It is considered that the root causes of OSD are accelerated growth as well as excessive sports and recreational activity. Currently, more than 50% of children of school age are involved in sports activities. In this study, 40 external risk factors were analyzed. The aim of this study was to determine external risk factors and to develop an algorithm for the prevention of injuries caused by overload syndrome through a detailed analysis of Osgood-Schlatter's syndrome.

Methods: The research has been conducted on 200 patients who were previously diagnosed with Osgood-Schlatter's syndrome. The participants were divided into two groups, each containing 100 patients, first group – aerobic sports (football and basketball) and the second group – anaerobic sports (karate and taekwondo). Personal information, anthropometric measurements, complete medical, and sports history were taken from the patients. A clinical examination was conducted by the researcher himself. This clinical study was prospective, comparative, analytical, and descriptive. The research was conducted in the Public Center for Sports Medicine of Canton Sarajevo. Software used for statistical data analysis was SPSS for Windows (version 20.0, SPSS Inc., Chicago, Illinois, USA) and Microsoft Excel (version 13 of Microsoft Corporation, Redmond, WA, USA).

Results: Patients experienced the first symptoms of OSD at 4 years (football) and 6 years (taekwondo). About 60% of patients who trained in anaerobic sports and 38% of patients who trained in aerobic sports trained other sports more often as well. The research showed that a higher percentage of patients who trained anaerobic sports trained multiple sports at the same time (karate 88%, and taekwondo 82%) compared to patients who trained aerobic sports

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(football 68%, and basketball 76%). Patients who trained in anaerobic sports were also more likely to engage in recreational activities (58.3%) compared to patients who trained in aerobic sports (41.7%).

Conclusion: The research showed that patients who trained in anaerobic sports more frequently trained more than one sport at the same time and spent more hours doing recreational activities compared to patients who trained in aerobic sports. By analyzing weekly physical activity, it was concluded that the rest is limited. Future research aims to identify risk factors so that children, parents, and trainers can be educated to work on prevention through teamwork.

Key words: Osgood-Schlatter disease; excessive physical activity; the algorithm of prevention for overload syndrome

INTRODUCTION

Osgood-Schlatter's syndrome (Osgood-Schlatter disease [OSD]) is caused by an accumulation of repeated microtraumas and is classified as a type of chronic injury called "overload syndrome" (1,2). Overload syndromes are not acute injuries followed by inflammation; they are chronic injuries with degenerative changes which impact the damaged tissue. In cases when sportsmen do not respect rest days in their training plan, overload syndrome can develop even with moderate-intensity training over a longer period. On the other hand, it can be caused by high-intensity training of short duration even if recovery time is respected (3,4). Overload reactions can be interpreted as the organism's biological response to repeated mechanical stimuli. If the strain caused by training by its quality and quantity exceeds the organism's threshold of tolerance, it will result in a bio negative reaction of the organism to structural insufficiency (e.g., anasthesia, apophysitis, entezitis, and stress fracture) (5,6). It is considered that the root causes of OSD are accelerated growth as well as excessive sports and recreational activity (1,3,7). In 2008, the National Council of Sports Medicine announced the results of the latest research, which showed that around 60 million children, age 6–18 years, participated in some form of organized sporting activity. At the same time, about 44 million of them were simultaneously involved in more than one form of sporting activity (8). Currently, more than 50% of children of school age are involved in sports activities (1). While very little research is done to identify risk factors which lead to overload syndrome impacting children and adolescents, most common factors are often said to be mistakes in the training process, use of improper technique, intensive and frequent training, trainings

and competitions that last an entire calendar year, frequent travel, and not enough rest days (9,10). Being aware of the risk factors represents the cornerstone of acting preventively (2,11,12). No previous studies have been found which offer a parallel analysis of aerobic and anaerobic sports as well as contact and non-contact sports. In this study, 40 external risk factors were analyzed. The risk factors were divided into six groups: Risk factors related to sport (26 factors), risk factors related to sports injuries (six factors), risk factors related to sports equipment (two factors), nutrition and liquidity replenishment as risk factors (three factors), and risk factors related to the sports environment (two factors). The pressure that parents and coaches put on children is listed as a special risk factor because of its increasing future importance. Information about possible risks of injuries is less accessible or even unknown among young athletes, which indicates that systematic registration of injuries both in sport and recreational activities is required. The OSD etiology is complex, which means more extensive research should be planned in the future. Since survey results showcase a high percentage of children and parents who are not familiar with overload symptoms, the results of this research should be used in practice by sportsmen, trainers, and parents. Since injuries caused by OSD are classified as chronic, the direct and indirect costs of their treatment are extremely high. Frequent medical examinations, expensive rehabilitation, time-consuming sports activities, and school obligations result in grave socio-economic and financial consequences. All of these factors potentially lead to an increased incidence of inactive children and an epidemic of obesity which indicates an urgent need to take preventive measures to reduce the frequency of injuries (4,11,13,14.). The purpose of this study

was to determine external risk factors and to develop an algorithm for the prevention of injuries caused by overload syndrome through a detailed analysis of Osgood-Schlatter's syndrome concerning different types of sport (football, basketball, karate, and taekwondo).

METHODS

The research has been conducted on 200 patients who were previously diagnosed with Osgood-Schlatter's syndrome. The participants were, depending on the type of sport in which they were involved, divided into two groups, each containing 100 patients, first group – aerobic sports (football and basketball) and the second group – anaerobic sports (karate and taekwondo). All patients were clinically examined by the use of the same subjective and objective criteria. Personal information, anthropometric measurements, complete medical, and sports history were taken from the patients. A detailed medical and sports history was taken for each patient to perform a cross-section and summation of the external risk factors that led to the appearance of Osgood-Schlatter's syndrome. The clinical examination of both knees on all patients was conducted by the researcher himself. The study was prospective, clinical, comparative, analytical, and descriptive. The research was conducted in the Public Center for Sports Medicine of Canton Sarajevo. For research purposes, medical records of examinees, sportsmen were used. Software used for statistical data analysis was SPSS for Windows (version 20.0, SPSS Inc., Chicago, Illinois, USA) and Microsoft Excel (version 13 of Microsoft Corporation, Redmond, WA, USA).

RESULTS

Using the ANOVA test, it was proven that the mean age of caratists was statistically significantly lower than the average age of subjects of other subgroups, $F = 3.511$; $p = 0.016$. In subgroups, the oldest was those who trained basketball (13.38 ± 1.36 years), then taekwondo (13.30 ± 1.71 years). The smallest average age was experienced by karate subjects (12.40 ± 1.71 years), then football (12.96 ± 1.88 years) (Table 1).

The average age of occurrence of pain or swelling below the knee for subjects in the aerobic sports group was 11.43 ± 1.84 years, while in the group of anaerobic sports, it was 11.82 ± 2.26 years. Using the ANOVA test, a statistically significant difference was not found between the examined groups ($p = 0.680$) and subgroups ($p = 0.821$) (Table 2).

Using the ANOVA test, it was found that taekwondo (4.70 ± 2.18 years) were trained for the longest time before the first appearance of pain in the knee, and the least basketball players (3.42 ± 2.28 years) ($p = 0.007$) were statistically significantly trained, and there was no statistically significant difference in the groups ($p = 0.235$) (Table 3).

Using the Chi-square test, it was found that respondents who trained anaerobic sports (60%), compared to aerobic sports subjects (38%), were statistically significantly more trained in other sports, Chi-square = 8.458; $p = 0.003$. Respondents who trained football and basketball in 19% of cases also trained other sports. However, respondents who trained karate in 31% of cases also trained other sports, and this percentage was 29.0% in the group of respondents who trained taekwondo,

TABLE 1. The average age of patients

Sport	<i>n</i>	<i>X</i>	SD	SEM	Minimum	Maximum
Football	50	12.96	1.88	0.26	5.00	15.00
Basketball	50	13.38	1.36	0.19	11.00	16.00
Karate	50	12.40	1.71	0.24	8.00	15.00
Taekwondo	50	13.30	1.71	0.24	6.00	15.00
F=3.511; p=0.016						
Aerobic sports	100	13.17	1.65	0.16	5.00	16.00
Anaerobic sports	100	12.85	1.76	0.17	6.00	15.00
F=1.751; p=0.187						

SEM: Standard error of mean, SD: Standard deviation

which was a statistically significant difference, Chi-square = 6.539; $p = 0.011$ (Table 4).

Using the Chi-square test, it was proven that subjects training anaerobic sports were more often included in more sports (karate 88%; and taekwondo 82%), compared to aerobic sports subjects (football 68%; and basketball 76%) ($p = 0.009$) (Table 5).

Using the Chi-square test, it was found that the subjects in anaerobic sports were statistically more frequent (58.3%) in recreational sports, compared to aerobic sports subjects (41.7%), Chi-square = 16.810; $p = 0.001$. Subjects who trained football in 18% of cases also dealt with recreational sports, while in basketball players, this percentage was slightly higher, 23.5%. However, 29.8% of karatists were involved in recreational sports, and this percentage was in the group of subjects who trained taekwondo 28.5%, which is a statistically significant difference, Chi-square = 16.272; $p = 0.001$ (Table 6).

Of the total number of subjects, 90% of aerobic sports subjects recreated the same sporting sport,

while in the group of anaerobic sports, this number was statistically significantly lower and amounted to 13%, Chi-square = 116.176; $p = 0.001$. Using the Chi-square test, a statistically significant difference was not found on the frequency of recreational activities of the same sport concerning the examined groups, Chi-square = 0.041; $p = 0.839$ (Table 7).

Using the ANOVA test, it was found that respondents who trained basketball as a basic sport, had a statistically longer training duration than those of other sports ($p = 0.001$). Analyzing the ratio of additional sports and recreational sports, a statistically significant difference in the duration of training was not found concerning the subgroups tested ($p = 0.522$). The average total number of hours spent by the respondents during the week, in physical activity, was statistically significantly the highest among basketball players, and it was 17.2 h, and the lowest for footballers, 15.7 h ($p = 0.031$) (Table 8).

In both examined groups, 36% of aerobic and 37% of anaerobic sports subjects respected the planned

TABLE 2. The average age of occurrence of Osgood-Schlatter disease

Sport	<i>n</i>	X	SD	SEM	Minimum	Maximum
Football	50	11.28	1.91	0.27	4.00	14.00
Basketball	50	11.58	1.77	0.25	7.00	15.00
Karate	50	12.38	3.03	1.84	8.00	12.00
Taekwondo	50	11.26	1.66	0.23	6.00	14.00
F=0.306; $p=0.821$						
Aerobic	100	11.43	1.84	0.18	4.00	15.00
Anaerobic	100	11.82	2.26	0.92	6.00	12.00
F=0.170; $p=0.680$						

SEM: Standard error of mean, SD: Standard deviation

TABLE 3. The average length of training at the time of pain in the knee

Sport	<i>n</i>	X	SD	SEM	Minimum	Maximum
Football	50	4.41	1.85	0.26	1.00	8.00
Basketball	50	3.42	2.28	0.32	00	9.00
Karate	50	3.82	1.61	0.22	1.00	7.00
Taekwondo	50	4.70	2.18	0.30	1.00	9.00
F=4.141; $p=0.007$						
Aerobic	100	3.91	2.12	0.21	00	9.00
Anaerobic	100	4.26	1.96	0.19	1.00	9.00
F=1.420; $p=0.235$						

SEM: Standard error of mean, SD: Standard deviation

TABLE 4. Frequency of training of additional sports

Sport	Additional sport		Total
	Yes	No	
Group			
Aerobic <i>n</i> (%)	38 (38.0)	62 (62.0)	100 (50.0)
Anaerobic <i>n</i> (%)	60 (60.0)	40 (40.0)	100 (50.0)
$\chi^2=8.458; p=0.003$			
Subgroups			
Football <i>n</i> (%)	19 (19.0)	31 (31.0)	50 (25.0)
Basketball <i>n</i> (%)	19 (19.0)	31 (31.0)	50 (25.0)
Karate <i>n</i> (%)	31 (31.0)	19 (19.0)	50 (25.0)
Taekwondo <i>n</i> (%)	29 (29.0)	21 (21.0)	50 (25.0)
$\chi^2=6.539; p=0.011$			

TABLE 5. Analysis of relationships: One sport versus more sports

Sport	<i>n</i>	One sports training (%)	
		One sports training (%)	More sports training (%)
Football	50	16 (32)	34 (68)
Basketball	50	12 (24)	38 (76)
Karate	50	6 (12)	44 (88)
Taekwondo	50	9 (18)	41 (82)
$\chi^2=8.417; p=0.009$			

vacations. Subjects from the group of anaerobic sports compared to aerobic sports, statistically significantly more often did not respect the planned daily, weekly, monthly, and seasonal breaks, Chi-square = 9.718; $p = 0.007$ (Table 9).

In the group with aerobic sports, the season had an average duration of 9.6 months, and in the anaerobic group of 10.0 months. Using the ANOVA test, a statistically significant difference in the length of the sports season was not established about the examined groups, $F = 2.432; p = 0.121$ (Table 10).

DISCUSSION

The first symptoms of OSD children had already with 4 years old (football) and 6 years (taekwondo), and we concluded that the early involvement of children in sport is the dominant external risk factors. Malina, Mostafavifar et al., Halilbašić et al., as well as many others consider that the incidence of overload syndrome has increased due to the early inclusion of children in sports. By analyzing the relationship, one sport in relation to

TABLE 6. Incidence of practicing recreational sports

Group	Recreational sports		Total
	Yes	No	
Aerobic <i>n</i> (%)	63 (41.7)	37 (75.5)	100 (50.0)
Anaerobic <i>n</i> (%)	88 (58.3)	12 (24.5)	100 (50.0)
$\chi^2=16.810; p=0.001$			
Subgroups			
Football <i>n</i> (%)	28 (18.5)	22 (44.9)	50 (25.0)
Basketball <i>n</i> (%)	35 (23.2)	15 (30.6)	50 (25.0)
Karate <i>n</i> (%)	45 (29.8)	5 (10.2)	50 (25.0)
Taekwondo <i>n</i> (%)	43 (28.5)	7 (14.3)	50 (25.0)
$\chi^2=16.272; p=0.001$			

TABLE 7. Analysis of average recreation

Average recreation	Group	
	Aerobic	Anaerobic
Are you recreating the same sport that you train?		
Yes <i>n</i> (%)	90 (90.0)	13 (13.0)
No <i>n</i> (%)	10 (10.0)	87 (87.0)
$\chi^2=116.176; p=0.001$		
Frequency		
Every day <i>n</i> (%)	20 (22.2)	2 (15.4)
2–3 times/week <i>n</i> (%)	32 (35.6)	7 (53.8)
Just on weekend <i>n</i> (%)	38 (42.2)	4 (30.8)
$\chi^2=0.041; p=0.839$		

more than one sport, we concluded that subjects of anaerobic sports, concerning aerobic sports, often trained more sports at the same time and had more hours of recreation. Hyman concluded that children often train more different sports at the same time, train in more clubs, which means they did not limit their activity to a particular season. By analyzing weekly physical activity, the average number of hours spent by the subjects in physical activity (basic sports, extra sports, and recreational sports) was 17.2 h, taekwondo 16.8 h, 16.7 karatists, and 15.7 h footballers, and we concluded that the number of hours which respondents spend during the week in the sport is very large, which means that the rest is limited. A very small percentage of subjects did not have additional sports or recreational activities: About 32% of footballers, 24% of basketball players, 12% of karate players, and 18% of taekwondo. Ristolainen et al. and Halilbašić et al. consider that recreation

TABLE 8. The average duration (in hours) that respondents time during the week, in physical activity (basic sports, extra sports, and recreational sports)

Sport	Basic	Extra	Recreational	Total	Aerobic	Anaerobic
Football	5.71	4.65	5.36	15.73		16.47
Basketball	6.93	5.18	5.10	17.22		
Karate	5.10	5.57	6.02	16.69		16.75
Taekwondo	6.16	4.96	5.72	16.84		
<i>p</i>	0.001	0.522	0.524	0.031		0.048

TABLE 9. Organization of free time and recreation

Do you have a planned daily, weekly, monthly, and seasonal vacation?	Group		Total
	Aerobic	Anaerobic	
Yes <i>n</i> (%)	36 (36.0)	37 (37.0)	73 (36.5)
Yes, but I don't respect it. <i>n</i> (%)	25 (25.0)	42 (42.0)	67 (33.5)
No <i>n</i> (%)	39 (39.0)	21 (21.0)	60 (30.0)

$\chi^2=9.718; p=0.007$

TABLE 10. Duration of the sport season

Group	<i>n</i>	<i>X</i>	<i>SD</i>	<i>SEM</i>	Minimum	Maximum
Aerobic	100	9.69	1.82	0.18	5.00	12.00
Anaerobic	100	10.07	1.60	0.16	6.00	12.00

$F=2.432; p=0.121$

SEM: Standard error of mean, SD: Standard deviation

additionally shortens the recovery time is carried out without control and expert supervision and is a very important external risk factor. The conclusion of the research of Ristolainen et al. and associates was that a small number of free days was the strongest risk factor in the onset of obsessive-compulsive disorder as an overload syndrome. In both examined groups, only 36% of aerobic and 37% of anaerobic respondents respected the planned vacations. In the group of aerobic sports, the average duration lasted 9.6 months, and in the group of anaerobic 10.0 months, while in both groups, there were respondents who trained for 12 months. Hyman came to the conclusion that the training process lasts throughout the year, which is beyond the traditional sports program. The conclusions of the study enabled the development of a prevention algorithm by reducing external risk factors in sports for all types of injuries of the type of overload syndrome. The goal of future research should be the

identification of risk factors to educate children, parents, and trainers teamwork on prevention.

Algorithm of the prevention

- Obligatory clinical examination of a specialist in sports medicine, before being included in the training process, and a pre-season clinical examination.
- Make a functional movement screen.
- Mandatory periodic inspections to detect potential damage in time.
- Children should be allowed to choose the kind of sport themselves, but they should also be allowed to change several sports until they decide what it wants.
- Every child needs to find a “real” sport, in which he will have the greatest chances of success.
- Adjust the type of sport to the age of the child.

Recommendation

Age	Form of sports activity
Younger than 5	Game and fun, but not active training
Age 5–7	Practice various forms of sports activities, freely, and without coercion (sports at school or sports academy)
Age 6–9	Running, swimming, gymnastics (recreational), or some other sport, but very low level of organized sport
Age 10–12	Low level of competitive sport
Age 13–14	Sports specialization

- Do not allow an early sports specialization for any kind of sport.
- Athletes should participate in only one team, especially if they have remarkable results and if they are a member of the team that is traveling frequently.
- Educated trainers who will adjust the quality and quantity of training to the age of children.

- The youngest categories should be trained by the most experienced and most skilled trainers.

Age	Frequency (per week)	Duration (minutes)	Pre-workout warming (minutes)	Stretching
<5	1–2	50–60	5–10	No
6–9	2	60	5–10	Dynamic (avoiding static stress)
10–14	3	60–90	5–10	Dynamic and static
15>	5	90–120	5–10	Dynamic and static

- Modify the training process according to the age and possibilities of the child's organism (obligatory warming and stretching before and after training, control of the intensity of training, limited repetition of sport-specific movements, strengthening of physical fitness – aerobic training and strength training to adapt to the age of the child, neuromuscular training). Basic guidelines based on practical experience and conclusions of previous research:
- Aerobic endurance training is recommended for the age group of 8–10 years.
- Anaerobic endurance training can be done with an age group of 12–14 years.
- In the pre-season, conditioning programs are recommended.
- Learning and mastering the correct technique.
- Adhering to the rules of the correct game.
- Frequency control of the performance (recommendation: One contest or a fight weekly).
- Vacation planning (daily, weekly, monthly, and annual).
- Appropriate equipment adapted to the type of sport.
- Required protective equipment.
- Good conditions for playing (terrain adapted to sports, and weather conditions).
- The training pad should be adapted to the type of sport. Avoid hard surfaces (concrete, tartan, and artificial grass) and permanent changes in the substrate.
- Adequate nutrition and fluid replacement, and weight control.
- Forbid the use of unauthorized funds and supplements.

- Provide medical coverage at sporting events.
- Provide education not only for trainers but also for athletes and parents themselves.
- Limit the forcing of children by parents or trainers.
- Long-term planning of the training process, especially when it comes to children and adolescents.

CONCLUSION

The research showed that patients who trained in anaerobic sports more frequently trained more than one sport at the same time and spent more hours doing recreational activities compared to patients who trained in aerobic sports. By analyzing weekly physical activity, it was concluded that the rest is limited. Future research aims to identify risk factors so that children, parents, and trainers can be educated to work on prevention through teamwork.

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