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ASSESSMENT OF ELECTROPHYSIOLOGICAL CHANGES IN THE HEART BY ANALYSING RESTING ELECTROCARDIOGRAPHIC RECORDING AND COMPARISON WITH SEATTLE CRITERIA IN TRAINED MALE 14–19 YEARS AGED VOLLEYBALL PLAYERS

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Cardiovascular arrest among athletes is prevalent in today's competitive world. As a result, a thorough and routine assessment is advised. The Seattle Criteria are one of the most widely accepted standards in the electrophysiological diagnosis and can reveal possible aberrant findings based on ECG values.

Aim of the study: This study aims to investigate the heart's electrophysiological adaptations in trained male volleyball players. This comparison study used the Seattle Criteria to evaluate whether training has a beneficial or negative impact on the heart.

Material and methods: In this study, 41 trained male volleyball players aged 14 to 19 were divided into three groups (14–15, 16–17, and 18–19). Each player's resting ECG was recorded and compared to the Seattle criteria. The Kruskal-Wallis nonparametric ANOVA was used, followed by the Mann-Whitney *U* test for significant outcomes.

Results: The Q-T interval differed significantly between the three groups ($p<0.05$). In Groups 2 and 3, ST depression was identified using ECG 23% and 8% of the time, respectively. In Groups 1, 2, and 3, ST elevation was detected in 60, 62, and 83% of ECGs, respectively. Group 1 had much longer ventricular depolarization and repolarization times. Sinus bradycardia, sinus arrhythmia, and early repolarization (ST elevation) are considered normal ECG findings in athletes, while a ST-segment depression (0.5 mm) is abnormal.

Conclusions: It can be inferred that the adaptive aspects of the electrophysiological alterations in the heart as a result of training may help justify the effective workload and prevent cardiac failure in athletes.

KEYWORDS: cardiac adaptation, resting ECG, Seattle Criteria, volleyball players

Background

In athletes, cardiovascular health is crucial. Measurement of heart rate under various settings (resting, submaximal, maximum, and recovery) and blood pressure monitoring are typical procedures for assessing cardiovascular fitness. The pumping of the heart and blood flow via the arteries are reflected in the evaluation of heart rate and blood pressure. The heart rate of athletes is also used to regulate training intensity, frequency, and duration. The majority of studies assessing cardiovascular fitness in athletes focus

on the mechanical features of the heart. A few incidences seen in sudden cardiac arrest of young players in recent decades have prompted experts to explore electrical abnormalities in the heart as a crucial issue in sports. The Seattle Summit reported in 2012 that some electrophysiological alterations in the heart are unhealthy in inactive people but are regarded as normal adaptive changes in trained athletes [1]. According to the Seattle Criteria study, electrophysiological alterations should be recognized as the primary variable in assessing cardiovascular fitness in athletes to prevent sudden cardiac arrest. Even after this finding, studies on the electrical alterations of the heart in trained athletes used to determine cardiovascular adaptations from training have not been adequately documented.

In trained athletes, electrophysiological alterations in the heart are fairly prevalent. Regular, intense exercise training causes structural and functional changes in the heart, which can be seen on a 12-lead electrocardiogram (ECG). Structural and functional alterations, according to [2], may increase the risk of heart-related illnesses in young athletes with inherited cardiovascular problems. Because of the frequent reports of these incidents, many sporting organizations require cardiovascular screening for all young competitors (under 18) before they may compete [3]. Until now, ECG has only been used to protect trained athletes from cardiovascular risks. There have been no studies to support the effectiveness of training in athletes using electrophysiological adaptive characteristics.

This study aimed to determine the effectiveness of physical training in players by evaluating a resting ECG and comparing it to the Seattle Criteria [1]. According to the Seattle Criteria, sinus bradycardia, sinus arrhythmia, and early repolarization (ST elevation) are adaptive traits in trained athletes and are regarded as typical findings. However, in trained players ST-segment depression (0.5 mm) is atypical. These changes in the electrophysiological adaptation can be attributed to the training workload based on these criteria. The effectiveness of the training workload in male volleyball players was investigated in this study. The volleyball game is made up of short bursts of fast, explosive movements. Jumping, diving, and running short distances are all movements associated with this game. Power, mobility, and brain synchronization are required for all activities related to this game. This game's three key components are power, height, and movement. Aside from them, agility, flexibility, and reaction speed are all important factors in player performance. This game's primary energy system is anaerobic, and it employs both aerobic and anaerobic glycolysis. This study was carried out on trained male volleyball players to see if the applied training workloads had any beneficial or harmful influences on the electrical activities of the heart (14–19 years of age). This study can be used to evaluate the impact of physical training on changes in the heart's electrical activities after exposure to the program.

Aim of the study

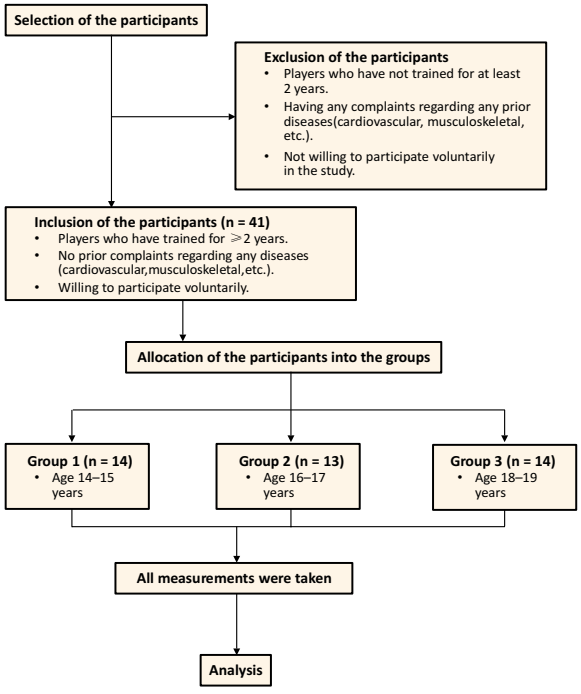
For the reason stated above, we investigated volleyball players' resting ECGs and compared them to the Seattle Criteria to see if training had any positive or negative effects on the heart. This study can assist trainers in diagnosing present conditions and planning training intensities and regimens to improve performance and cardiovascular fitness and manage negative effects as a precautionary measure.

Material and methods

Selection of participants

This study was conducted at the Department of Physiology, Serampore College, University of Calcutta (please see details on the flowchart below). There were forty-one male volleyball players that ranged in age from 14 to 19. None of them were reported to have any additional physical ailments. Each subject was tested using the National Standard of Living Index (NFHS) and the Sports Competition Anxiety Test (SCAT). These 40 trained male volleyball players were divided into three groups according to their age.

(a) Group 1: Age 14–15 years,
(b) Group 2: Age 16–17 years,
(c) Group 3: Age 18–19 years.



The following measurements were performed on each volleyball player.

Methods

Anthropometry and body fat measurement

Stature and body mass were measured using the Seca height measurement scale and Seca weighing scale. BMI was calculated according to the equation [4] given below:

- BMI = body weight (kg)/body height (m^2).
- Biceps, Triceps, Subscapular, and Supraspinale skinfold thicknesses were measured using an Innovare skinfold caliper (Cescorf) that required a constant closing compression of 10 g/mm^2 across the range of measurements. During the measurement, participants were told to keep their body regions relaxed as skinfold thickness can vary from one location to the next. The generalized equation [5] was used to calculate Body Density (kg/mm^3). The conventional equation [6] was used to compute Total Body Fat percentages (%). Using the values of Total Body Fat percentage (%) and Body Mass, the Total Fat Mass (kg) was calculated. The Lean Body Mass (kg) was computed by subtracting the Total Fat Mass (kg) from each subject's Total Body Mass (kg).

Equations for calculating Body Density (kg/mm^3), Total Fat percentage (%), and Total Fat Mass (kg) are provided below:

- Body Density = 1.1620 – 0.0630 log (Biceps + + Triceps + Subscapular + Supraspinale) for male 14–19 years old.
- Total Body Fat percentage (%) = ((4.45/Body density) – 4.142) × 100.
- Total Body Fat Mass (kg) = (% of Body Fat/100) x Body Weight in kg.
- Lean Body Mass (kg) = Total Body Mass or Weight (kg) – Total Fat Mass (kg).

Cardiovascular measurements

Each individual had their resting heart rate (beats per minute), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), pulse pressure (mmHg), and an ECG obtained.

After 30 minutes of repose in a sitting position, resting heart rate (beats per minute) was monitored.

Each volleyball player's systolic blood pressure (mmHg) and diastolic blood pressure (mmHg) were measured in a sitting position using a Standard Electronic Sphygmomanometer. Each volleyball player's ECG was performed in a supine position on a flat surface. The machine used was a BPL Cardiart 6208R automated 12 lead machine. In this study, Bazett's Correction [7] was performed using the formula:

- Bazett's Formula = QT interval/square root of the RR interval.
- P (ms), QRS (mv), T (mv), PR interval (ms), QT interval (ms), QTC (ms), ST-segment (ms), and J point were calculated from the ECG measurement.

Ethics

Prior to the study, voluntary consent from each player and their respective club authorities was obtained. Serampore College's Institutional Human Ethical Committee accepted the study protocol. All players were under the necessary supervision of coaches, according to the club's report. The training programs were tailored to the players' physical needs and abilities.

Statistical analysis

All statistical analysis was done using IBM SPSS v25 software. For each age group, the mean and standard deviation of the variables were computed as descriptive statistics. The Shapiro-Wilk test was used to ensure normal distribution, which revealed that the data were not normally distributed. Kruskal-Wallis non-parametric ANOVA was used to examine each variable between the three age groups. The intergroup differences of the significant variables were determined using the Mann-Whitney *U* multiple comparison test. For all statistical outcomes, a p-value of <0.05 was considered significant.

Results

As per the Kruskal-Wallis nonparametric Anova, Age and stature were shown to be significant disparities among the three groups (Table 1). Body mass, BMI, body fat percentage, total fat content, and lean body mass did not differ significantly across the three groups (Table 1).

Heart rate (beats/min), pulse pressure (mmHg), and QT interval (ms) were significantly different across the three groups (Table 2). Groups 2 and 3 had considerably higher pulse pressures and QT intervals, respectively.

According to the Mann-Whitney *U* test, there were no age differences between the three groups (Table 3). Group 2 has a substantially higher status than Group 1 (Table 3). Group 2 had a considerably lower resting heart rate than group 1, and group 3 had the lowest resting heart rate (Table 3). Group 1 had a much lower pulse pressure than groups 2 and 3. Group 1 had a considerably longer QT interval than group 2 (Table 3).

Table-1. Measured physical variables in volleyball players

Variables	Volleyball Players Group (Means ±SD)			Level of Significance
	Group 1 (n=14) [Age 14–15 years]	Group 2 (n=13) [Age 16–17 years]	Group 3 (n=14) [Age 18–19 years]	
Age (years)	14.71±0.31	15.97±0.40	18.65±0.69	p<0.05
Stature (cm)	159.13±7.00	164.44±7.10	172.53±9.19	p<0.05
Body Mass (kg)	53.79±11.91	59.06±12.37	63.76±12.79	NS
BMI (kg/m^2)	21.16±4.12	21.82±4.09	21.41±3.66	NS
Body Fat (%)	18.25±5.14	17.25±5.78	14.57±4.51	NS
Total Fat Content (kg)	10.31±4.68	10.639±5.27	9.70±4.58	NS
Lean Body Mass (kg)	43.48±7.51	48.38±7.81	54.06±8.98	NS

n – Sample size; p – Probability of significance; NS – Not significant].

Table 2. Measured cardiovascular variables in volleyball players

Variables	Volleyball Players Group (Mean ±SD)			Level of Significance
	Group 1 (n = 14) [Age 14–15 years]	Group 2 (n = 13) [Age 16–17 years]	Group 3 (n = 14) [Age 18–19 years]	
Heart Rate (beats/min)	82.93±15.46	77.92±16.00	67.43±13.02	p<0.05
Systolic Blood Pressure (mmHg)	122.93±13.67	134.08±13.11	125.07±12.12	NS
Diastolic Blood Pressure (mmHg)	70.21±9.35	71.08±6.80	71.57±11.91	NS
Pulse Pressure (mmHg)	52.71±10.22	63.00±10.04	53.50±12.82	p<0.05
P (ms)	99.00±5.70	95.85±6.66	101.71±10.84	NS
PR interval (ms)	134.14±13.14	125.85±14.15	137.71±17.90	NS
QRS (mv)	1.38±0.29	1.36±0.48	1.52±0.41	NS
QT interval (ms)	353.86±27.29	352.00±15.30	378.00±23.05	p<0.05
QTc	412.07±22.17	398.62±37.38	398.29±38.41	NS
T (mv)	0.37±0.11	0.34±0.11	0.43±0.12	NS
ST segment in V4 (ms)	2.95±0.65	2.50±0.71	2.66±0.65	NS
ST segment in V5 (ms)	3.29±0.67	2.99±0.78	3.43±0.84	NS

n – Sample size; p – Probability of significance; NS – Not significant.

Table 3. Mann-Whitney U test in volleyball players

Variables	Volleyball Players Group		
	Group 1 vs Group 2	Group 2 vs. Group 3	Group 1 vs. Group 3
Age (years)	NS	NS	NS
Stature (cm)	58.500, p<0.05	NS	NS
Heart Rate (beats/min)	74.000, p<0.05	59.500, p<0.05	NS
Pulse Pressure (mmHg)	50.000, p<0.05	NS	90.500, p<0.05
QT interval (ms)	87.000, p<0.05	NS	NS

p – Probability of significance; NS – Not significant.

The ST elevation and ST depression percentages seen in the pie chart (Figure 1) were 68% and 10%, respectively. Isoelectric lines were seen in 22% of volleyball players (Figure1). Figure 2 shows ST elevation to be present in 60% of group 1 participants (14–15 years old), 62% of group 2 (16–17 years old), and 83% of group 3. (18–19 years).

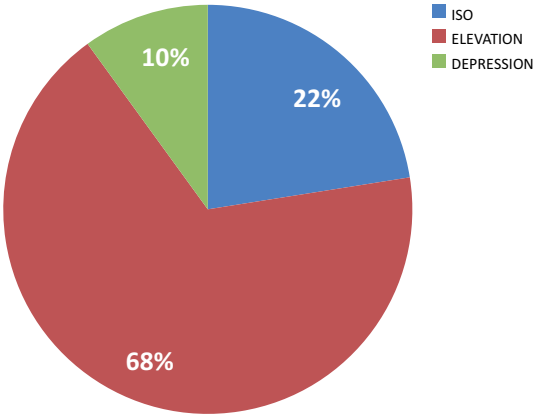


Figure 1. Percentage of isoelectric ST segment, ST elevation, and ST depression in volleyball players

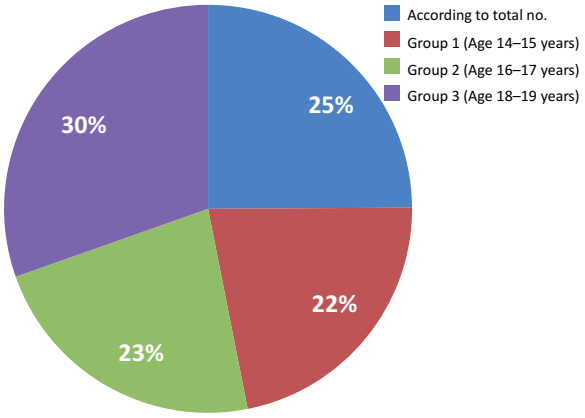


Figure 2. Percentage ST elevation in volleyball players

Discussion

Volleyball is a sport that requires strength, agility, and quickness [8]. All of these physical characteristics are linked to the player's cardiovascular and respiratory changes. As a result, without suitable training to modify cardiovascular activity, players' performance levels at the international level of competition will be inadequate. In addition to improving cardiac output and oxygen extraction at the tissue level, training lowers myocardial oxygen needs for the same amount of external exertion [9].

Except for stature, the statistically insignificant results in the physical characteristics among the three groups show that, while age differences exist among the three groups, they have little effect on the volleyball players' general physical characteristics (Table 1). This could be because of the training effect, which reduces age-related developmental differences between the three groups. A pronounced growth spurt in group 2 could explain the considerable difference in stature between the two groups.

The lowest resting heart rate was in the highest age group (18–19 years) implying a significant training effect on heart rate. The force generated by the heart each time it contracts is known as systemic pulse pressure. It is inversely proportional to the aorta's elasticity and approximately proportionate to stroke volume [10]. Significant differences in pulse pressure across the three groups suggest that it is age-related, and the volleyball players' cardiovascular systems are influenced by physical exercise.

Physical training has no electrophysiological influence on atrial depolarization, repolarization, or conduction times from the SA node to the AV node of the heart, according to statistically negligible differences between the three groups. The highest ventricular depolarization and repolarization levels were seen in 18–19 years old and could be attributed to training-induced ventricular hypertrophy.

On an ECG, the ST segment represents an electrically neutral portion between ventricular depolarization and repolarization (QRS complex, T wave). The ST segment is the interval during which the myocardium contracts to evacuate blood from the ventricles [11]. Myocardial ischemia or infarction is the most common cause of ST-segment abnormalities (elevation or depression). ST elevation is deemed typical, while ST depression (0.5 mm) is considered abnormal in trained athletes, according to the Seattle Criteria. Only one subject (group 2) had ST depression greater than 0.5 mm, which could be indicative of aberrant ECG abnormalities.

The largest elevations (86%) were in the 18–19 year age group and the lowest elevations (60%) were in the 14–15 year age group which could be attributed to the volleyball players' training and age-related changes. Using the Seattle criterion, this study asserts that volleyball players can change their ventricular depolarization and repolarization parameters through physical training. The 22% of participants that had no change in their isoelectric line, neither elevation nor depression, suggests that physical activity is insufficient to trigger ventricular alterations.

This research also considers the relationship between training and physical adaptability in trained athletes. The Seattle Criteria are used to compare the percentage of ST elevation and ST depression. Sinus bradycardia, sinus arrhythmia, and early repolarization (ST elevation) are all considered normal ECG findings in athletes, according to the Seattle Criteria.

When evaluating typical variations in athletes, these common training-related ECG abnormalities represent physiological responses to regular exercise. In athletes, aberrant ECG abnormalities include ST-segment depressions (≥0.5 mm) and atrial tachyarrhythmias. It can be concluded that adaptive electrophysiological alterations as a result of training may be useful in justifying a player's efficacy.

Limitation

There are several limitations of this study. As part of the growing age population, the age groups evaluated were not actually prone to any cardiovascular illnesses at this time. Although the Seattle Criteria are one of the most frequently acknowledged recommendations, there are a variety of factors that might affect cardiovascular health, ranging from illnesses to training protocols. So there is always a need for more research in various age groups and genders to back up these assertions.

Conclusions

The facts are that regular vigorous exercise training can lead to anatomical and functional changes in the heart. Sinus bradycardia, sinus arrhythmia, and early repolarization (ST elevation) are all considered normal ECG findings in athletes, according to the Seattle Criteria. When evaluating typical ECG variations in athletes, these common training-related ECG abnormalities represent physiological responses to regular exercise.

Using the Seattle Criteria to measure the effectiveness of physical training on cardiac development and interpreting ECGs in trained volleyball players is a novel technique, according to this study. In light of this, various electrical activities of the heart were recorded using an ECG. The Seattle Criteria were used to compare these numbers. ECG interpretation can be used to assess the effectiveness of training in terms of heart development. More studies are needed to prove the value of these interpretations in trained athletes.

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ANTHROPOMETRY AND BODY COMPOSITION OF YOUNG SOCCER PLAYERS

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Body composition and other anthropometric measurements are important factors influencing the overall performance of an athlete. Together with motor coordination, physical fitness, physical, functional, and psychosocial conditions, as well as learned technique and tactics, a player's sports potential and probability of success can be determined.

Aim of the study: Our study aimed to describe anthropometric variables and body composition of young soccer players of various ages.

Material and methods: A cross-sectional study was carried out among 61 young soccer players in the under-15, under-16, and under-19 categories. We used a bioimpedance analyzer to measure the following indicators: body height (BH), body mass (BM), body mass index (BMI), total body water (TBW), muscle mass (MM), fat mass (FM), body fat (BF) percentage, and visceral fat (VF).

Results: The mean findings for the variables among players in the U-15, U-17, and U-19 groups were age (14.79±0.32; 16.07±0.44; 17.43±0.87), BH (175.63±7.36 cm; 179.89±7.49 cm; 180.28±6.42 cm), BM (62.32±8.13 kg; 67.38±8.14 kg; 73.81±8.86 kg), BMI (20.15±1.88 kg/m^2; 20.77±1.58 kg/m^2; 22.68±2.18 kg/m^2), TBW (40.72±5.19 L; 44.13±5.18 L; 47.63±5.58 L), MM (31.18±4.26 kg; 34.06±4.22 kg; 37.11±4.64 kg), FM (6.8±2.68 kg; 7.12±2.48 kg; 8.72±2.72 kg), BF (10.83±3.6%; 10.47±2.83%; 11.79±3.09), and VF (1.83±1.09; 1.89±1.2; 2.61±1.33). Analysis of variance showed statistically significant differences between groups in terms of age, BM, BMI, MM, and TBW. Age had a statistically significant positive correlation with BH, BM, BMI, TBW, MM, and FM.

Conclusions: BM, MM, and TBW increase in the subsequent age groups of soccer players. There was a statistically significant positive correlation between age and BH, BM, BMI, TBW, MM, and FM. The conclusion from this study can help adjust training programs to the individual characteristics of a given player, which will allow for better performance and professional success.

KEYWORDS: body composition, muscle mass, fat mass, young soccer players

Background

Anthropometric variables and body composition are important components of success in sports, including football [1]. Body composition is strongly related to the physical fitness and achievements of a football player [2]. Body composition is one of the factors that when combined with technical/tactical, physical, functional, and psychosocial factors can determine the athlete's athletic potential and the likelihood of success in a given sport [3,4]. However, studies on the influence of anthropometric variables and body composition on soccer performance are not clear-cut, mainly due to the player's position, but also due to the player's individual physique. Nevertheless, monitoring body composition can help players im-

prove their performance and evaluate the results of the administered training plan [5].

In soccer, both body fat and lean body mass should be monitored. An appropriate fat level allows players to move more efficiently during training and matches. Lean mass and muscle mass (excessive or inadequate) can lead to undesirable changes in the body, that can affect performance factors such as speed, strength, power, and risk of injury [6].

Body composition, combined with physical, functional, and psychosocial factors, is one of the factors that can determine athletic potential and the likelihood of success in a given sporting discipline [7]. In the case of soccer players, the level of body fat and lean body mass should be constantly monitored. The right amount of fat is an energy reserve that allows players to maintain efficiency during training and matches. Lean body mass is also important, especially muscle mass. Too much of a training load with too little muscle mass can reduce performance factors such as speed, strength, and power, as well as increase the risk of injury and recovery time after exercise [8].

Changes in body composition based on age are well recorded in nonathletic adult and adult soccer players and have been correlated with health and athletic performance. But there is little research on body composition, age, and performance of adolescent soccer players. Leão et al. found an increase in lean body mass and a decrease in fat mass with age and training [9], while Manna et al. arrived at the opposite conclusion [10]. As such, further research into body composition changes in adolescent footballers is necessary. In addition, it is necessary to take into account periods sensitive to the development of physical abilities (e.g. puberty, growth spurt) and the appropriate adjustment of training units and proper nutrition.

The variability of anthropometric indices and body composition parameters in this period of adolescence can be used to identify an elite teenage player [11,12]. There are reports that soccer players with increased body dimensions have improved speed, power, and strength, especially during puberty [13]. Conversely, several longitudinal observational studies of teenage soccer players have shown a high consistency in anthropometric measures, sprint speed, lower extremity explosive power, isokinetic strength, and maximum aerobic speed among players [14, 15].

Aim of the study

This study aimed to describe the anthropometric variables and body composition of young soccer players in various age categories.

Material and methods

Study design

A descriptive, comparative cross-sectional study.

Settings

Our study was conducted in March of 2019 among U-15, U-16, and U-19 soccer players belonging to the MKS Mosir Opole in Poland. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies [16].

Participants

The sample of participants consisted of a total of 61 young soccer players from the MKS Mosir Opole divided into three subsamples. The first subsample of subjects consisted of 24 players in the U-15 group with a mean age of 14.8±2.2, the second subsample consisted of 19 players in the U-17 group with a mean age of 16.1±2.8, and the last subsample of examinees consisted of 18 players in the U-19 group with a mean age of 17.4±4.9. The soccer players were examined during the 2018–2019 season. The inclusion criteria were: (1) male gender, (2) regularly training for football at MKS Mosir Opole in Poland, (3) lack of contraindications to performance of the measurements using bioelectric impedance, (4) signed informed consent/parental or guardian consent in players under 18 years of age. The exclusion criteria included any injuries, contusions, or health problems that might affect the study's results.

Ethical Considerations

The study was approved by the Bioethics Committee of the Opole Medical School, Poland (No. KB/42/NOZ/2019). The study was carried out in accordance with the ethical guidelines of the Declaration of Helsinki and Good Clinical Practice guidelines [17].

Measurement

All measurements were conducted by highly skilled, trained, and experienced physiotherapists and nutritionists. Anthropometric variables included body height (BH, measured while the participant was standing erect against a portable stadiometer without shoes, in 0.1 cm increments), body mass (BM, in 0.1 kg increments), calculated body mass index (BMI; in kg/m^2), and body composition indices (BM, BMI, total body water (TBW), muscle mass (MM), fat mass (FM), body fat (BF) percentage, and visceral fat (VF)), which were measured by bioelectri-

cal impedance analysis using the InBody 120 scale. The scale was used according to the manufacturer's guidelines. Standardized conditions for bioimpedance measurements were maintained. The InBody 120 scale enables athletes to closely monitor their body weight and health condition with all relevant parameters.

Testing took place during the morning hours. Participants were asked not to consume any supplements or pharmacological agents that could influence the measurement results 24 hours prior to body composition measurements. They were also instructed not to eat or drink before the measurements and to maintain good hydration and a normal routine. Furthermore, the athletes did not perform high-intensity physical activity for any significant duration 48 hours before the tests. Players were assessed before training sessions and after urination.

Participants followed the prompts from the device. During the measurements, participants placed their bare feet on the metal plates of the system, firmly grasped the handles, and placed all fingers in standardized places.

The player was then asked to align their heels and forefeet with the electrodes on the measurement scale to ensure the maximum contact area. The player was also asked to align their thumbs, fingers, and palms to maximize the contact area with the electrodes while holding onto the device handles. During the procedure, participants were instructed to extend their elbows and slightly abduct their shoulders to ensure that their arms and legs were not in contact with any other body segments.

Once the proper positioning was achieved, the player was asked to stand still and remain silent while the device completed the body composition measurements, which took 17 seconds on average. The investigators administered and supervised the entire test to ensure that the player maintained proper positioning and did not move.

The accuracy of these measurements is estimated to be 98% compared to DEXA, i.e. a densitometric test. The InBody scale has been extensively tested for its reliability and validity, and reports have shown that these metric traits have been appropriate in various trials, including active people and athletes [18, 19, 20].

Statistical methods

The data obtained during the survey were collated using Microsoft Excel. Statistical analyses were conducted using Statistica version 13.1 (TIBCO Software Inc., USA). The basic description of quantitative variables such as mean (M), median (Me), minimum (Min), maximum (Max), 1st quartile (Q1), 3rd quartile (Q3), standard deviation (SD), and coefficient of variation (CV) was made during the preparation of the results. The distribution of the variables was assessed in terms of normality using the Shapiro-Wilk test. The analysis of variance (ANOVA) and post hoc NIR tests were used to compare quantitative variables. The chi-square test was used to evaluate and compare the correlation between age and body composition. The level of statistical significance for this study was set at a $p\text{-value} < 0.05$.

Results

Participants

A sample of the participants consisting of 61 young soccer players, divided into three subsamples. The first subsample consisted of 24 players (29.4%) under-15, the second subsample consisted of 19 players (31.1%) under-17, and the last subsample consisted of 18 players (29.5%) under-19.

Descriptive data

Descriptive statistics for the age and body composition of the players are presented in Tables 1–3.

Table 1. Characteristics of age, anthropometric variables, and body composition in the U-15 group.

Variables	M	Me	Min	Max	Q1	Q3	SD	CV
Age [years]	14.8	14.8	14.0	15.2	14.6	15.1	0.3	2.2
BH [cm]	175.6	177.5	160	192	172	180.5	7.4	4.2
BM [kg]	62.3	62.1	47.3	75.9	55.6	69.1	8.1	13.1
BMI [kg/m^2]	20.2	19.7	16.4	24.2	19.1	21.4	1.9	9.4
TBW [L]	40.7	41.4	30.9	48.4	37.4	45.4	5.2	12.7
MM [kg]	31.2	31.6	23.1	38.2	28.5	35	4.3	13.7
FM [kg]	6.8	6.2	2.3	13.3	4.8	8.8	2.7	39.5
BF [%]	10.8	9.9	3.5	19.3	8.3	12.9	3.6	33.3
VF [rating]	1.8	1.5	1	5	1	2	1.1	59.5

Notes: BH: body height, BM: body mass, BMI: Body Mass Index, TBW: total body water, MM: muscle mass, MF: fat mass, BF: % of body fat, VF: visceral fat, M: mean, Me: median, Min: minimum, Max: maximum, Q1: 1st quartile, Q3: 3rd quartile, SD: standard deviation, CV: coefficient of variation.

Table 2. Characteristics of age, anthropometric variables, and body composition in the U-17 group

Variables	M	Me	Min	Max	Q1	Q3	SD	CV
Age [years]	16.1	16.1	15.3	16.9	15.9	16.2	0.4	2.8
BH [cm]	179.9	180	167	199	175	183	7.5	4.2
BM [kg]	67.4	66.5	54.5	82.8	61.8	73.3	8.1	12.1
BMI [kg/m^2]	20.8	20.2	18.2	24.7	19.8	22.1	1.6	7.6
TBW [L]	44.1	43.7	35.9	55.9	39.5	47.9	5.2	11.7
MM [kg]	34.1	34	27.4	43.3	30.4	37.2	4.2	12.4
FM [kg]	7.11	6.7	4.3	14.4	5.4	7.8	2.5	34.9
BF [%]	10.5	10.6	6.3	17.4	8.2	11.6	2.8	27
VF [rating]	1.9	2	1	5	1	2	1.2	63.2

Notes: BH: body height, BM: body mass, BMI: Body Mass Index, TBW: total body water, MM: muscle mass, MF: fat mass, BF: % of body fat, VF: visceral fat, M: mean, Me: median, Min: minimum, Max: maximum, Q1: 1st quartile, Q3: 3rd quartile, SD: standard deviation, CV: coefficient of variation.

Table 3. Characteristics of age, anthropometric variables, and body composition in the U-19 group

Variables	M	Me	Min	Max	Q1	Q3	SD	CV
Age [years]	17.4	17.7	15.5	19.2	16.9	18	0.9	4.9
HB [cm]	180.3	181	169	191	175	185	6.4	3.6
BM [kg]	73.8	72.4	60.7	89.7	68.2	78.6	8.9	12
BMI [kg/m^2]	22.7	22.8	19.5	27.1	21	24.61	2.2	9.6
TBW [L]	47.6	46.8	36.8	57.2	43.8	52	5.6	11.7
MM [kg]	37.1	36.2	28.2	45.4	33.7	40.9	4.6	12.5
FM [kg]	8.7	8.3	4.9	15.9	7	10.4	2.7	31.2
BF [%]	11.8	11.2	7.2	17.8	9.3	14.2	3.1	26.2
VF [rating]	2.6	2	1	6	2	3	1.3	51.1

Notes: BH: body height, BM: body mass, BMI: Body Mass Index, TBW: total body water, MM: muscle mass, MF: fat mass, BF: % of body fat, VF: visceral fat, M: mean, Me: median, Min: minimum, Max: maximum, Q1: 1st quartile, Q3: 3rd quartile, SD: standard deviation, CV: coefficient of variation.

The mean age of players in groups U-15, U-17, and U-19 group was 14.8 ± 0.3, 16.1 ± 0.4, and 17.3 ±0.9, respectively. In each subsequent age group, there was an increase in BH, BM, BMI, TBW, MM, FM, and VF.

Main results

ANOVA testing revealed differences between groups with respect to age (F=113.7; p<0.001), BM (F=9.7; p<0.001), BMI (F=9.6; p<0.001), MM (F=9.5; p<0.001), TBW (F=8.8; p<0.001), while there were no differences with respect to BH (F=2.9; p=0.066), BF (F=0.8; p=0.443), FM (F=2.9; p=0.057), VF (F=2.5; p=0.090) as shown in Table 4.

The post hoc NIR test confirmed statistically significant differences between all groups of variables such as Age (U-15<U-17, p<0.001; U-15<U-19, p<0.001; U-17<U-19, p<0.001), TBW (U-15<U-17,

Table 4. Analysis of variance (ANOVA) — effects and errors of age, anthropometric variables, and body composition

Variables	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
Age [years]	74.2	2	37.1	19.9	58	0.3	113.7	<0.001
BH [cm]	290.4	2	145.2	2955.0	58	50.9	2.9	0.066
BM [kg]	1357.9	2	678.9	4047.1	58	69.8	9.7	<0.001
BMI [kg/m^2]	68.8	2	34.4	207.2	58	3.6	9.6	<0.001
TBW[L]	494.7	2	247.3	1631.9	58	28.1	8.8	<0.001
MM [kg]	362.9	2	181.5	1104.8	58	19.1	9.5	<0.001
FM [kg]	41.5	2	20.8	402.1	58	6.9	2.9	0.058
BF [%]	17.2	2	8.6	604.7	58	10.4	0.8	0.443
VF [rating]	7.2	2	3.6	83.4	58	1.4	2.5	0.091

Notes: BH: body height, BM: body mass, BMI: Body Mass Index, TBW: total body water, MM: muscle mass, MF: fat mass, BF: % of body fat, VF: visceral fat, SS: sum of squares; df: degree of freedom; MS: mean square; F: the value of the F statistic, p: p-value.

p<0.05; U-15<U-19, p<0.001; U-17<U-19, p<0.05), and MM (U-15<U-17, p<0.05; U-15<U-19, p<0.001; U-17<U-19, p<0.05). Statistically significant differences were found in BM (U-15<U-19, p<0.001; U-17<U-19, p<0.05), and BMI (U-15<U-19, p<0.001; U-17<U-19, p<0.01). These results are shown in Table 5.

Other analyses

There was a statistically significant positive correlation between Age and BH (r=0.3; p<0.05), BM (r=0.5; p<0.001), BMI (r=0.5; p<0.001), TBW (r=0.5; p<0.001), MM (r=0.5; p<0.001), and FM (r=0.3; p<0.05) as shown in Table 6.

Table 5. Post hoc NIR test in age, anthropometric variables, and body composition

Variables	Group	M	U-15	U-17	U-19
Age [years]	U-15	14.8		U-15<U-17***	U-15<U-19***
	U-17	16.1	U-15<U-17***		U-17<U-19***
	U-19	17.4	U-15<U-19***	U-17<U-19***	
BM [kg]	U-15	62.3		n.s	U-15<U-19***
	U-17	67.4	n.s		U-17<U-19*
	U-19	73.8	U-15<U-19***	U-17<U-19*	
BMI [kg/m^2]	U-15	20.2		n.s	U-15<U-19***
	U-17	20.8	n.s		U-17<U-19**
	U-19	22.7	U-15<U-19***	U-17<U-19**	
TBW [L]	U-15	40.7		U-15<U-17*	U-15<U-19***
	U-17	44.1	U-15<U-17*		U-17<U-19*
	U-19	47.6	U-15<U-19***	U-17<U-19*	
MM [kg]	U-15	31.2		U-15<U-17*	U-15<U-19***
	U-17	34.1	U-15<U-17*		U-17<U-19*
	U-19	37.1	U-15<U-19***	U-17<U-19*	

Notes: BM: body mass, BMI: Body Mass Index, TBW: total body water, MM: muscle mass, M: mean, significant differences are marked: *p<0.05, **p<0.01, ***p<0.001, n.s.: nonsignificant differences between compared pairs.

Table 6. Spearman's Rank correlation between age, anthropometric variables, and body composition

Variable		BH [cm]	BM [kg]	BMI [kg/m2]	TBW [L]	MM [kg]	FM [kg]	BF [%]	VF [ratio]
Age [years]	r	0.260	0.510	0.490	0.490	0.520	0.280	0.10	0.24
	p	0.040	<0.001	<0.001	<0.001	<0.001	0.030	n.s.	n.s.

Notes: BH: body height, BM: body mass, BMI: Body Mass Index, TBW: total body water, MM: muscle mass, FM: fat mass, BF: body fat, VF: visceral fat, r: value of coefficient r, p: p-value, n.s.: nonsignificant differences.

Discussion

Key results

The study aimed to analyze the differences in anthropometric variables and body composition in young soccer players from three different age groups. The players in the U-19 group were heavier and had a higher BMI compared to the U-15 and U-17 players. The mean BMI of each group was within the normal range. Differences in TBW and MM were also significant. The youngest group (U-15) had the lowest TBW and lowest MM. The oldest group (U-19) had the highest TBW and MM.

Interpretation

The higher BMI in U-19 players may be associated with a greater MM. The older age and longer training periods of U-19 players likely result in an increase in MM and a greater body weight and BMI. Other authors have also found differences in body weight, BMI, and body composition parameters in young players of different ages. A study conducted in the Czech Republic showed that the age of the footballer has a significant impact on the MM of the lower limbs. Researchers observed an increase in the percentage of MM with age [21]. Research by Spehnjak et al. evaluated Serbian footballers of different ages and found players in the U-15 group were the lightest and had the lowest BMI, MM, and TBW compared to players from the U-17 and U-19 groups. There were no significant differences between the U-17, U-19, and senior groups [22]. In studies by Bernal-Orozco et al., the youngest age category of footballers also had the lowest values in body weight and MM [7].

Here, the author found the U-15 group was heavier and had a higher BMI, MM, and TBW compared to the U-15 group in the study by Spehnjak et al. The differences in results for the U-15 group may be because the Serbian footballers in the U-15 group were younger (mean age 13.7±1.9) compared to the Polish U-15 players (mean age 14.8±0.3) [22]. In turn, players in the U-15 group from our research were taller and had a greater body weight and lower fat content compared to 14-year-old Portuguese soccer players [23].

In a study by Konarski et al., select and non-select U-15 male soccer players differed significantly in terms of estimated maturity, body size, muscle mass, body proportion, and functional tests. MM differed significantly ($p<0.05$) and was larger in the select players compared to the non-select players (45.5 vs. 40.9). Both select and non-select players had a much higher MM compared to the U-15 soccer players from our research. The soccer players from our research also had a lower FM than players from the research by Konarski et al. (select and non-select, 14.8% vs. 15.6%, respectively) [24].

The U-17 and U-19 results obtained in our study were similar to the results obtained in these age groups in the Serbian research [22]. Here, the authors found no significant differences between groups regarding the percentage of adipose tissue and VF. However, other researchers have observed different results. In the study by Spehnjak et al., differences in BF were significant. The U-15 group had a significantly higher percentage of BF compared to the U-17 and U-19 groups [22]. A study of young Greek soccer players showed no differences between age groups regarding BF, but a weak significant negative correlation between BF and age was found [25]. In Mexican soccer players, the youngest age group had the highest percentage of BF [7].

Age was a significant factor in most of the parameters on the build and body composition of young footballers. The authors' own research showed positive significant correlations between age and height, body weight, BMI, MM, TBW, and FM. There were no significant correlations between age and BF or VF. However, the relationship between age and BF percentage may not be clear. The overall increase in body weight with age and a greater gain in lean mass could have resulted in a lower relative proportion of BF mass as the absolute amount of BF as measured in kilograms increased with age in our football groups. Milson et al. came to a similar conclusion [11]. An interesting result is the fact that the examined players had similar BF in all groups.

The growth and maturity characteristics of youth male soccer players are well documented. Given the popularity of soccer throughout the world, there is considerable interest in the growth and maturation of young players [26, 27, 28, 29].

Strengths

The strength of our study was the use of standardized methods to assess body composition. In addition, this study broadens the knowledge on the body composition characteristics of young footballers in particular age categories.

Limitations

Our study also has several limitations. This study was conducted only within one club. It is possible that conducting the test at different clubs with lower or higher levels would have produced different results. In addition, we did not divide the players according to their playing position due to the relatively small number of participants. Therefore, the generalization of this data is limited.

In subsequent studies, the anthropometric data and body composition of players should be taken and observed longitudinally, taking into account variables such as the timing of puberty (allowing the determination of the peak velocity of growth). Research should also be carried out to include functional testing and comparisons based on anthropometric features. The other limitation is the lack of information on the number of games and duration of play in each game for the individual players and the lack of information on the injury of a player during the course of a season. It is worth considering these variables in future research.

Recommendations

Anthropometric variables and body composition provide objective and specific information that allows professionals in the medical, nutritional, physical, and technical industries to develop strategies to improve individual player performance through exercise and diet plans that optimize body composition. In particular, this information can assist with nutritional assessments and the subsequent monitoring of the athlete's nutrition from an early age to adulthood and in the setting of body composition goals. In addition, this data can be useful for strength and conditioning practitioners in designing effective and specific training programs according to the most suitable anthropometric and body composition profile of each player.

CONCLUSIONS

Overall, the U-19 division obtained higher anthropometric and body composition values compared

to all other age divisions, with the youngest group having the lowest values for most variables. Soccer players in subsequent age groups had increased body weight, MM, and TBW. Soccer players had statistically significant differences with regard to body composition except in FM, BF, and VF. There were statistically significant positive correlations between age and the body composition component BH, BM, BMI, TBW, MM, and FM. Future research should include the relative age effect on anthropometry, body composition, and biological maturation in young Polish soccer players.

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IMPACT OF THE COVID-19 PANDEMIC ON VITAMIN D, BLOOD GLUCOSE, AND LIPID PROFILES IN THE TURKISH POPULATION

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: The frequency of 25-hydroxyvitamin D (vitamin D) deficiency may have increased due to less sun exposure during the COVID-19 pandemic. On the contrary, considering the data indicating that vitamin D deficiency increases susceptibility to respiratory tract infections, more people may have chosen to take vitamin D supplements as a precaution during the pandemic.

Aim of the study: To assess how the pandemic affected vitamin D levels, blood glucose levels, and lipid profiles in a Turkish population.

Material and methods: This retrospective single-center study was conducted at a university hospital. Data about age, gender, comorbidities, vitamin D_3, blood glucose, and lipid profiles were obtained from the hospital database. The patients were grouped into pre-pandemic (before 10 March 2020) and pandemic periods (between 10 March 2020 and 10 March 2021) and compared in terms of vitamin D, blood glucose, lipid profile, and other metabolic parameters.

Results: The hospital records of 8,658 patients were examined in this study. Of these, 3,551 (41.0%) were from the pre-pandemic period, and 5,107 (59.0%) were from the pandemic period. Females accounted for 5,980 (69.1%) of the patients, and the mean age was 44.15±16.72. The mean vitamin D level was significantly higher during the pandemic than during the pre-pandemic period ($p<0.001$; 21.30±11.92 ng/mL vs. 19.89±11.33 ng/mL, respectively). There were significant differences between the pre-pandemic and pandemic periods in blood glucose, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides ($p<0.05$).

Conclusions: This study determined that vitamin D, blood glucose, LDL, and triglyceride levels increased, while HDL levels decreased, during the COVID-19 pandemic in a Turkish population.

KEYWORDS: blood glucose, COVID-19, lipids, pandemic, vitamin D

Background

25-hydroxyvitamin D (vitamin D) plays a pivotal role in numerous physiological mechanisms that maintain homeostasis in the body. There is an increased susceptibility to respiratory tract infections in cases of vitamin D deficiency [1,2]. Vitamin D exerts anti-inflammatory and antimicrobial properties. A study that previously examined the relationship between vitamin D levels and coronavirus disease 2019 (COVID-19) showed that vitamin D deficiency was more common among patients with

COVID-19 [3]. Although not all studies of the relationship between vitamin D and COVID-19 are consistent, it is thought that vitamin D supplementation can limit the development and severity of COVID-19. Thus, a tendency for more people to consume vitamin D supplements during the COVID-19 pandemic has been observed. As a result, vitamin D levels in the population may have increased during the pandemic period compared to the pre-pandemic period.

On the other hand, outside activities and therefore sun exposure decreased during quarantine, which was implemented to control the spread of the virus. This may have resulted in decreased vitamin D levels. In addition, people may have had problems accessing vitamin D-rich foods due to disruptions in many service sectors, high costs, and unemployment.

Apart from vitamin D, blood glucose regulation and blood lipid concentrations may have been adversely affected due to reasons such as decreased daily activity, increased high carbohydrate snack consumption due to stress and boredom, and disrupted routine hospital visits during the pandemic. One of the comorbidities seen as a risk factor for severe COVID-19 is diabetes mellitus (DM). It has been reported that DM causes an increase in mortality related to acute respiratory distress syndrome in COVID-19 patients [4].

Societies may react differently to the restrictions and stressors of the pandemic. Therefore, countries should research the indirect effects of the pandemic on public health, identify problems caused by the pandemic, and plan preventive actions in their societies. In this study, the effects of the COVID-19 pandemic on vitamin D and other metabolic parameters were investigated in a Turkish population.

Aim of the study

The aim of this study was to evaluate the effect of the COVID-19 pandemic on vitamin D, blood glucose, and lipid profiles in a Turkish population.

Material and methods

Sample

This retrospective, single-center, observational study investigating differences in vitamin D_3 levels and metabolic parameters during the COVID-19 pandemic was performed at Akdeniz University Hospital. As the study was retrospective, it was not possible to obtain written informed consent from the patients.

Patients who presented to the Akdeniz University Medical Faculty Hospital Internal Diseases outpatient clinic between 10.03.2019 and 10.03.2021 and whose vitamin D levels had been measured were included in the study. All of the patients were over 18 years old. The exclusion criteria were as follows: patients with a diabetes diagnosis less than two years earlier; patients using corticosteroids; patients with newly diagnosed hypothyroidism/hyperthyroidism; patients with liver disease or chronic kidney disease; and patients with granulomatous diseases such as tuberculosis and sarcoidosis.

Methods

Data about age, gender, comorbidities, vitamin D, blood glucose, creatinine, LDL, HDL, triglycerides, thyroid-stimulating hormone (TSH), free thyroxine (T4), ferritin, vitamin B12, and hemoglobin levels were obtained from the hospital database. We categorized vitamin D levels as deficient at < 20 ng/ml, low at 21–29 ng/ml, adequate at 30–150 ng/ml, and toxic at > 150 ng/ml. The patients were grouped according to hospital admission dates as pre-pandemic period (before 10 March 2020) and pandemic period (between 10 March 2020 and 10 March 2021), and the listed parameters were compared between groups.

Ethics

Ethical approval for the study was obtained from the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee (decision no: KAEK-559-560, dated: 18.08.2021). The study was conducted according to the principles of the Declaration of Helsinki.

Statistical analysis

Descriptive statistics were presented as numbers and percentages for categorical variables and as mean, standard deviation, and median for continuous variables. The Kolmogorov–Smirnov test was used to check whether the data conformed to a normal distribution. Comparisons between groups were made using the Mann–Whitney U and chi-square tests. Spearman's correlation was used to evaluate the correlation between variables. The statistical analysis was conducted using IBM SPSS Statistics version 23.0 software (IBM Corp., Armonk,

NY, USA). A p-value <0.05 was considered statistically significant.

RESULTS

Descriptive data

The hospital records of 8,658 patients were examined in this study. Of these, 3,551 (41.0%) were from the pre-pandemic period, and 5,107 (59.0%) were from the pandemic period. Females accounted for 5,980 (69.1%) of the patients, and the mean age was 44.15±16.72 (Table 1). The mean vitamin D level was 20.72±11.70 ng/mL (Table 2).

Table 1. Age and gender of the patients

Variables	All patients	Groups	
		Pre-pandemic period	Pandemic period
n (%)	8,658 (100%)	3,551 (41.0%)	5,107 (59.0%)
Gender n (%*)			
Male	2,678 (30.9%)	1,038 (29.2%)	1,640 (32.1%)
Female	5,980 (69.1%)	2,513 (70.8%)	3,467 (67.9%)
Age (Mean±Std)	44.15±16.72	43.76±17.48	44.43±16.16

Gender characteristics of the patients are given as number and percentage.
Age characteristics are given as mean and standard deviation.
* Column percentage was used.

Table 2. Metabolic parameters and vitamin D levels of the patients

Variables	All patients	Groups		p values
		Pre-pandemic period	Pandemic period	
	Ort±Ss (Ortanca)	Ort±Ss (Ortanca)	Ort±Ss (Ortanca)	
25-hydroxyvitamin D3 (ng/mL) (n=8,658)	20.72±11.70 (18.49)	19.89±11.33 (17.73)	21.30±11.92 (18.99)	**<0.001**
Creatinine (mg/dL) (n=7,569)	0.749±0.241 (0.710)	0.745±0.246 (0.710)	0.752±0.238 (0.710)	0.060
LDL (mg/dL) (n=6,045)	122.76±38.01 (120.20)	121.20±38.23 (118.50)	123.68±37.84 (121.10)	**0.010**
HDL (mg/dL) (n=5,186)	50.59±14.24 (48.50)	51.94±14.26 (50.20)	49.67±14.16 (47.50)	**<0.001**
Triglycerides (mg/dL) (n=5,927)	141.65±112.84 (115.00)	130.11±93.28 (107.00)	148.67±122.72 (121.00)	**<0.001**
Glucose (mg/dL) (n=7,053)	95.53±34.42 (87.00)	91.46±30.42 (85.00)	98.01±36.41 (89.00)	**<0.001**
Vitamin B12 (pg/mL) (n=7,667)	355.44±192.48 (313.00)	349.48±191.64 (307.00)	359.44±192.96 (317.00)	**<0.001**
Hemoglobin (g/L) (n=8,056)	13.31±1.74 (13.30)	13.27±1.72 (13.20)	13.33±1.75 (13.30)	0.058
Ferritin (ng/mL) (n=6,829)	51.46±77.36 (27.50)	52.37±71.20 (29.20)	50.84±81.28 (26.50)	**0.001**
TSH (uIU/mL) (n=7,102)	2.16±6.05 (1.62)	2.05±3.33 (1.57)	2.23±7.28 (1.65)	0.055
T4 (ng/dL) (n=6,206)	1.1764±0.2135 (1.1600)	1.1718±0.1925 (1.1600)	1.1794±0.2260 (1.1700)	0.389

HDL: high density lipoprotein; LDL: low density lipoprotein; TSH: thyroid-stimulating hormone; T4: free thyroxine

The parameters of the patients are given as mean±standard deviation and median.
The results of the Mann-Whitney U test, in which the pre-pandemic period and pandemic period values were compared, are given as p-values. Statistically significant results are indicated in bold.

Main outcomes

Effect of the pandemic on vitamin D levels

A statistically significant difference was found for vitamin D levels between the pre-pandemic period and the pandemic period (p<0.05). Vitamin D deficiency was more common during the pre-pandemic period, and the number of patients with adequate vitamin D levels was higher during the pandemic period compared to the pre-pandemic period (Table 3). There was a statistically significant difference in vitamin D levels between the male and female patients (p<0.05). The vitamin D levels of the female patients were lower than those of the male patients in both the pre-pandemic and pandemic periods (Table 4). The vitamin D levels

Table 3. Distribution of patients according to 25-hydroxyvitamin D_3 levels

Vitamin D levels	All patients n (%*)	Groups		p value
		Pre-pandemic period n (%*)	Pandemic period n (%*)	
Deficient	4,887 (56.4%)	2,126 (59.9%)	2,761 (54.1%)	**<0.001**
Inadequate	2,575 (29.7%)	986 (27.8%)	1,589 (31.1%)	
Adequate	1,194 (13.8%)	439 (12.4%)	755 (14.8%)	
Toxic	2 (0.0%)	0 (0.0%)	2 (0.0%)	

Vitamin D levels are given as numbers and percentages.
The results of the chi-square test, in which the pre-pandemic period and pandemic period values were compared, are given as p-values. Statistically significant results are indicated in bold.
* Column percentage is used.

Table 4. Distribution of 25-hydroxyvitamin D_3 levels by gender

Period	Gender	25-hydroxyvitamin D3		p values
		Mean±Std	Median	
Pre-pandemic period	Female (2,513)	19.65±11.83	17.43	**<0.001**
	Male (1,038)	20.49±9.97	18.57	
Pandemic period	Female (3,467)	20.95±12.40	18.53	**<0.001**
	Male (1,640)	22.04±10.79	20.22	
Both periods	Female (5,980)	20.40±12.18	18.05	**<0.001**
	Male (2,678)	21.44±10.50	19.60	

Vitamin D values according to gender are given as mean±standard deviation and median.
Results of the Mann-Whitney U test, in which the values of females and males were compared, are given as p-values. Statistically significant results are indicated in bold.

were significantly higher during the pandemic compared to the pre-pandemic period for both genders.

Effect of the pandemic on blood glucose and lipid profiles

There were statistically significant differences in the blood glucose levels and lipid profiles between the pre-pandemic and pandemic periods ($p<0.05$). HDL levels were lower, while blood glucose, LDL, and triglycerides were higher during the pandemic period compared to the pre-pandemic period (Table 2). There was a negative correlation between triglycerides and vitamin D levels, while age, creatinine, HDL, vitamin B12, hemoglobin, ferritin, and T4 were positively correlated with vitamin D levels (Table 5).

Table 5. Correlation between 25-hydroxyvitamin D3 and other parameters

Variables	r	p*
Age	0.113	**<0.001**
Glucose	0.007	0.564
Creatinine	0.142	**<0.001**
LDL	0.022	0.084
HDL	0.073	**<0.001**
Triglycerides	-0.130	**<0.001**
Vitamin B12	0.191	**<0.001**
Hemoglobin	0.073	**<0.001**
Ferritin	0.096	**<0.001**
TSH	–0.051	**<0.001**
T4	0.154	**<0.001**

HDL: high-density lipoprotein; LDL: low-density lipoprotein; TSH: thyroid-stimulating hormone; T4: free thyroxine

The relationships between the patients' vitamin D values and the other parameters are indicated by the correlation coefficient. The results of the Spearman correlation test, which examined the relationship between the vitamin D values and the other parameters, are given as p-values. Statistically significant results are indicated in bold.

Discussion

This study demonstrated that the mean vitamin D level of the patients was higher in the pandemic period compared to the pre-pandemic period. Vitamin D toxicosis was more common in the pandemic period than in the pre-pandemic period, but it was still quite rare. Only two patients in the pandemic period had toxic vitamin D levels, while there was no vitamin D toxicosis in the pre-pandemic period. Compared to the pre-pandemic period, there were fewer patients with vitamin D deficiency and more

patients with adequate vitamin D levels during the pandemic period. Female patients had lower vitamin D levels than male patients for both the pre-pandemic and pandemic periods. Vitamin B12 levels were higher during the pandemic period than during the pre-pandemic period. This suggests that patients may have taken vitamin D and vitamin B12 supplements during the pandemic period to protect themselves from COVID-19. It was also observed that the pandemic had a negative impact on fasting blood glucose levels and lipid profiles. The patients' fasting blood glucose, LDL, and triglyceride levels were higher during the pandemic than during the pre-pandemic period, while HDL levels were lower during the pandemic period.

Based on the anti-inflammatory and antimicrobial properties of vitamin D, it has been suggested that vitamin D supplementation could protect people from developing COVID-19. A study investigating the relationship between vitamin D levels and COVID-19 infection revealed that vitamin D deficiency is more common in patients with COVID-19 [3]. It has also been suggested that there may be a relationship between vitamin D levels and the severity of COVID-19 [5]. However, a causal relationship between vitamin D and COVID-19 has not yet been established. This is because the low vitamin D levels of patients who develop COVID-19 may actually be a result of COVID-19. In a previous study, vitamin D levels were initially measured in nine healthy volunteers. Then, a polysaccharide obtained from *Escherichia coli* was injected to trigger systemic inflammation; vitamin D levels and simultaneous interleukin 6, interleukin 8, and tumor necrosis factor levels were measured after the injection [6]. It was observed that vitamin D levels decreased and were inversely correlated with elevated inflammatory markers during the peak period of inflammation. They concluded that systemic inflammation reduced vitamin D levels. The low vitamin D levels measured during COVID-19 may be mediated by a similar mechanism.

The low vitamin D levels observed in COVID-19 patients may be cause or effect, but this finding neither proves nor excludes the possible beneficial effects of vitamin D supplementation during or before COVID-19 [7]. Although this issue has not yet been clarified, it has generally been observed that people use vitamin D supplements to protect themselves from COVID-19. However, such widespread and uncontrolled use of a drug can be risky because vitamin D toxicity has potentially serious consequences [8,9]. Vitamin D is known to increase calcium absorption from the gastrointestinal tract, and vitamin D intoxication causes hypercalcemia and hypercalciuria. Although its efficacy against COVID-19 has not yet been proven, intensive use of vitamin D may cause vitamin D toxicosis, which can result in muscle weakness, hypertension, neuropsychiatric disorders, gastrointestinal distress, polyuria, polydipsia, kidney stones, and, in extreme cases, kidney failure. It should also be kept in mind that the accumulation of calcium phosphate crystals in tissues can cause cardiac arrhythmias (low action potential), calcification of coronary vessels and heart valves, and potentially even death. This study found that while there was no vitamin D toxicosis before the pandemic, vitamin D toxicosis developed in two patients during the pandemic period.

Pandemics may cause an increase in the consumption of snacks rich in carbohydrates and a decrease in daily activity. Together, these can result in blood glucose and lipid dysregulation. However, the reaction of a population to the pandemic can vary. A study investigating the effect of lockdowns on patients with type 1 DM determined that blood glucose parameters were not significantly affected despite dietary habits and physical activities being adversely affected [10]. During the pandemic, Spanish patients with type 2 DM increased vegetable consumption and decreased fast food consumption while under quarantine [11]. There was no significant difference in glucose parameters between the pre-pandemic and pandemic periods [12]. In the present study, mean fasting blood glucose and glycated hemoglobin (HbA1c) levels were higher during the pandemic period compared to the pre-pandemic period. The effects of the pandemic on blood glucose may differ depending on whether the patient has DM or not. Furthermore, reactions to the pandemic may differ according to the capability of the population to manage stressors. Since patients with DM are aware they have the disease, they can act more carefully. However, patients who are prone to DM may lose control of their blood glucose regulation during the pandemic.

Inactivity and a high-calorie diet due to stress may have resulted in negatively affected blood lipids during the pandemic period [13]. LDL and triglyceride levels were higher, and HDL levels were lower, during the pandemic compared to the pre-pandemic period.

The findings from this study suggest that the burden of pandemics goes beyond the known direct harm and that attention should be paid to their harmful indirect long-term effects on cardiometabolic health. Given the current COVID-19 pandemic, these findings may inform public health prevention strategies to reduce the impact of future cardiometabolic diseases [14].

Limitations

This study has numerous limitations. The patients who were examined from the pre-pandemic

period may not be the same as those examined during the pandemic. The patients who were considered controls during the pandemic period may have had some health problems. Therefore, there may be differences between the patients in the pre-pandemic period and the pandemic period. Additionally, this study did not assess the factors that may affect a patient's glycemic parameters, such as lifestyle changes during quarantine, adherence to diet, stressors, and access to medications. This information could help us interpret the results with greater certainty.

Conclusions

The pandemic seems to have had a positive effect on the vitamin D levels of the Turkish population. However, vitamin D toxicosis was more common during the pandemic. The pandemic adversely affected the blood glucose levels and lipid profiles of the Turkish population studied. We believe that it is essential to identify the indirect health effects of pandemics. Knowing the secondary effects of the pandemic will enable us to take preventive and corrective actions going forward.

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PROPERTIES AND FUNCTIONS OF MYELOPEROXIDASE AND ITS ROLE IN OVARIAN CANCER

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Elevated levels of myeloperoxidase in body fluids are increasingly being used as an indicator for the diagnosis of cancer.

Aim of the study: The aim of this study was to review the literature on the physical and chemical properties of myeloperoxidase, its role in carcinogenesis, the role of tumor-associated neutrophils in cancer, and the role of myeloperoxidase in ovarian cancer.

Material and methods: The research literature published between January 1999 and December 2019 was reviewed. The properties and role of myeloperoxidase in the development of ovarian cancer were selected from publications available in selected online databases, including MEDLINE, PubMed, Scopus, and Web of Science. Searches were performed using the following word combinations: "myeloperoxidase", "ovarian cancer", "reactive oxygen species", "expression", "polymorphism", and "tumor-associated neutrophils".

Results: Thirty-five scientific articles were included in the final review. Of the 35 articles, 11 discussed the role of myeloperoxidase in carcinogenesis, and five discussed its role in the development of ovarian cancer.

Conclusions: Elevated myeloperoxidase levels are associated with many types of cancer, including ovarian cancer. In the studied group of invasive ovarian tumors, up to 65% exhibited elevated levels of myeloperoxidase. Continued research on myeloperoxidase expression in ovarian cancer cells is vital and warranted.

KEYWORDS: myeloperoxidase, ovarian cancer, polymorphism, G-463A polymorphism

Background

Epithelial ovarian cancer (EOC) is one of the most deadly and insidious gynecological cancers in women because it does not present with specific symptoms until late in its course. Approximately 230,000 women are diagnosed with ovarian cancer each year worldwide, and over 150,000 die as a result of this terrible disease. EOC belongs to the group of the seven most diagnosed cancers among women in the world. Its 5-year survival rate is 46% [1]. Risk factors for EOC include, but are not limited to, lifelong ovulation (no pregnancy, early menstrual age, late menopause), family history of EOC, smoking, mild gynecological diseases (including endometriosis, polycystic ovary syndrome, and pelvic inflammatory disease), and, possibly, talcum powder use [2]. The last factor is particularly controversial. The use of talcum powder on the genitals can induce significant changes in key redox enzymes and improve the status of prooxidants in normal and EOC cells. Studies have shown a significant, dose-dependent increase in iNOS prooxidant, nitrate/nitrite, and myeloperoxidase in cells exposed to talcum powder [3].

Myeloperoxidase (an enzyme belonging to the peroxidase group) is a protein that plays a crucial role

in the nonspecific antibacterial defense system. This enzyme is released in the process of phagocytosis and catalyzes oxidation reactions in the presence of hydrogen peroxide, halide, or thiocyanate to appropriate acids, which are strong and effective antimicrobial substances. As myeloperoxidase produces these compounds, various inflammatory reactions occur, and tissue damage ensues [4]. Patients with gynecological cancers have elevated plasma myeloperoxidase levels and tissue expression [5].

Currently, attempts to improve methods of treating ovarian cancer are heavily focused on overcoming resistance to platinum analogues, hyperthermic intraperitoneal chemotherapy, immunotherapy, and personalized medicine. Efforts are constantly being made to discover new and better therapeutic goals based on personalized medicine (adapting the medicine to a given patient). In this article, we review the literature on the role of myeloperoxidase in the carcinogenesis of ovarian cancer.

Aim of the study

The aim of this study was to investigate and present the importance of myeloperoxidase, its expression, and its polymorphisms in ovarian cancer.

Material and methods

Search strategy and study selection

The research literature published between January 1999 and December 2019 was reviewed using the electronic databases MEDLINE, PubMed, Scopus, and Web of Science. The search was conducted using the following words: "myeloperoxidase", "ovarian cancer", "reactive oxygen species", "expression", "polymorphism", and "tumour-associated neutrophils".

The following inclusion criteria were used: (I) articles written in English; (II) articles published between January 1999 and December 2019; (III) articles about the properties of myeloperoxidase and its significance in ovarian cancer; (IV) original and review articles; and (V) articles based on human studies. Articles involving animal studies and studies published as conference reports or letters to the editor were excluded from this review.

Data extraction

To minimize bias, three independent reviewers (BGB, AGB, and LB) assessed the articles based on abstracts during the search. If a study was deemed "relevant", the entire manuscript was assessed; the study was considered "relevant" if it met the inclusion criteria and was not excluded for the reasons mentioned above. When analyzing the article, the completeness of the following data was noted: first author's name, reference, year of publication, type of publication, country, and aim of the study.

A total of 3,375 articles were identified in the search. Thirty-five articles published from 1999 to 2019 and one published in 1989 (describing the isolation of myeloperoxidase) were included in the final review.

Results

A total of 3,375 articles were identified through the search of MEDLINE, PubMed, Scopus, and Web of Science. After excluding duplicate articles, 2261 were included for review. After careful analysis of these articles, some were excluded because they did not meet the inclusion criteria. The remaining 1,085 articles were further reviewed and analyzed. Of these, 998 were excluded because they were commentaries on articles and conference papers that did not contain the data required for this review; at this point, 87 articles remained. Fifty-three more articles were then excluded, leaving 34 articles published from 1999 to 2019 that were ultimately included in the review. One article from 1989 was focused on the isolation of myeloperoxidase (Figure 1).

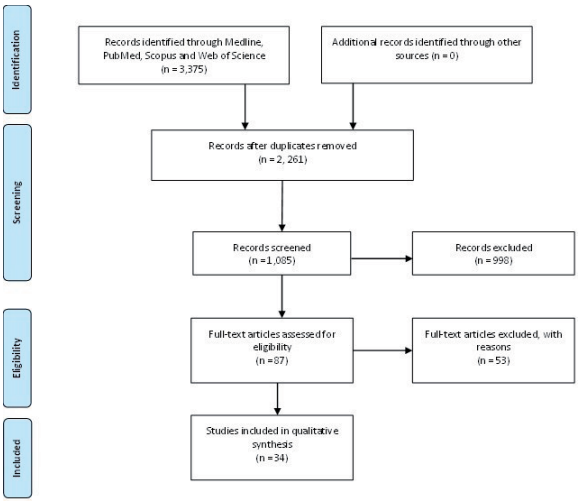

Figure 1. Flowchart of study selection

As a result, 34 articles published between 1999 and 2019 met the criteria for inclusion in this review paper. A summary and description of these articles are presented in Table 1.

Myeloperoxidase

Malle et al. demonstrated that myeloperoxidase (MPO EC 1.11.1.7) is an enzyme belonging to the per-

Table. 1. Characteristics of the included articles

Authors	Reference	Year of publication	Type of publication	Country	Aim of the study
Malle E et al.	[6]	2007	Review	Austria	Physico-chemical properties of MPO
Davies MJ	[7]	2010	Review	Australia	Physico-chemical properties of MPO
Nauseef WM	[8]	2014	Review	USA	Physico-chemical properties of MPO
Furtmüller PG et al.	[9]	2006	Review	Austria	Structure and properties of MPO
But PG et al.	[10]	2003	Review	Russia	Structure and properties of MPO
Ikeda-Saito M et al.	[11]	1989	Research Article	USA	Properties and isolation of MPO
Kettle AJ et al.	[12]	2001	Research Article	New Zealand	Properties and activity of MPO
Klebanoff SJ	[13]	2005	Review	USA	Structure, properties, and importance of MPO
Khan AA et al.	[14]	2018	Review	Saudi Arabia	Structure, properties, and importance of MPO; Role of MPO in different diseases
Atwal M et al.	[15]	2017	Research Article	UK	Hypochloric acid and its importance
Ikwegbue PC et al.	[16]	2019	Review	Africa	Hypochloric acid and its importance
Zhu H et al.	[17]	2006	Research Article	China	MPO G-463A polymorphism in various types of neoplasms
Qin X et al.	[18]	2013	Meta-analysis	China	MPO G-463A polymorphism in various types of neoplasms
Cascorbi I et al.	[19]	2000	Research Article	Germany	MPO G-463A polymorphism in various types of neoplasms
Feyler A et al.	[20]	2002	Research Article	France	Myeloperoxidase (MPO) polymorphism
Stevens JF et al.	[21]	2008	Review	USA	The role of acrolein in carcinogenesis
Tang M et al.	[22]	2011	Review	USA	Acrolein and DNA damage
Tsou HH et al.	[23]	2019	Research Article	Taiwan	Acrolein and DNA damage
Fridlender ZG et al.	[24]	2012	Review	USA	Tumor-associated neutrophils
Ghatalia P et al.	[25]	2019	Research Article	USA	Tumor-associated neutrophils
Wang J et al.	[26]	2019	Research Article	China	Tumor-associated neutrophils
Trellakis S et al.	[27]	2011	Research Article	Germany	Tumor-associated neutrophils and head and neck cancer
Banat GA et al.	[28]	2015	Research Article	Germany	Tumor-associated neutrophils and lung cancer
Fossati G et al.	[29]	1999	Research Article	Italy/UK	Neutrophil infiltration into human gliomas
Reid MD et al.	[30]	2011	Research Article	USA	Tumor-infiltrating neutrophils in pancreatic neoplasia
Shen M et al.	[31]	2014	Meta-analysis	China/Denmark	Tumor-associated neutrophils as a new prognostic factor in cancer
Fridlender ZG et al.	[32]	2009	Research Article	USA	Tumor-associated neutrophils
Mishalian I et al.	[33]	2013	Research Article	Israel	Tumor-associated neutrophils
Zeindler J et al.	[34]	2019	Research Article	Switzerland	Tumor-associated neutrophils and MPO
Mayer C et al.	[35]	2016	Research Article	Germany	Neutrophil granulocytes in ovarian cancer
Fletcher NM et al.	[36]	2012	Research Article	USA	MPO and free iron levels
Olson SH et al.	[37]	2004	Research Article	USA	Polymorphisms of the MPO gene in patients with ovarian cancer
Castillo-Tong DA et al.	[38]	2014	Research Article	Austria/Germany/ USA	Myeloperoxidase and ovarian cancer
Droeser RA et al.	[39]	2016	Research Article	Switzerland	Myeloperoxidase and ovarian cancer
Dai Y et al.	[40]	2018	Research Article	China/USA	The MPO encapsulation process by metal phenolic nanoparticles

oxidase group that is stored in the azurophilic granules of neutrophils. It constitutes 2% to 5% of all proteins in these cells. Myeloperoxidase is also present in monocytes, Kupffer cells, and glial cells. It plays a vital role in defending the body against pathogens and microorganisms [6]. Davies et al. reported that, during inflammation, activated neutrophils secrete myeloperoxidase into the phagosomes and intercellular spaces of infected sites. Activation of these cells is the result of the production of hydrogen peroxide

during NADPH oxidation in aerobic respiration. Myeloperoxidase uses hydrogen peroxide to oxidize halide (Cl^-, Br^-, I^-) and pseudohalide (SCN^-) ions to generate hypochlorous (HOCl), hypobromous (HOBr), hypoiodous (HOI), and hypothiocyanous (HOSCN) acids. All of these acids are strong and effective antimicrobial molecules [7]. The most rapid and complete antimicrobial action by human neutrophils against many organisms relies on the combined efforts of the azurophilic granule protein myeloperoxidase and hydrogen peroxide from the NADPH oxidase to oxidize chloride, thereby generating HOCl and a host of downstream reaction products [8].

Physical and chemical properties of myeloperoxidase

Myeloperoxidase is a cationic glycoprotein with a molecular weight of 146 kDa composed of two symmetrically arranged dimers (73 kDa) joined by a disulphide bridge formed by Cys153 residues [1,6]. Each dimer consists of a 14.5 kDa light subunit of 108 amino acids and contains one intra-disulphide chain linkage. The 58.5 kDa heavy subunit is made up of 466 amino acids, and its structure is stabilized by five intra-disulphide bonds [4,6]. Five glycosyl asparagine residues are located in the heavy subunit: Asn157, Asn189, Asn225, Asn317, and Asn565. Asn317-related sugar residues are found in the space between dimers and play a large role in their formation [9].

Each myeloperoxidase dimer consists of 19 α-helices, a small number of β-turns, an iron ion covalently bound to a heme molecule, and a calcium ion [9]. The heme molecule found in every myeloperoxidase dimer is located in a special pocket shaped by a core consisting of five α-helices, one of which comes from the light subunit. All peroxidases in which the chemical group is a prosthetic group contain in their active center an iron ion (Fe^{3+}) coordinated with a macrocyclic tetrapyrrole ring of protoporphyrin IX. In myeloperoxidase, the methyl groups of the A and C heme pyrrole rings are modified and form ester bonds with the Glu242 heavy subunit and the Asp94 light subunit carboxyl groups. The calcium ion binding site has the characteristic shape of a pentagonal bipyramid. This ion is bound by the oxygen atom of the Ser174 hydroxyl group and the oxygen atom of the Phe170 carbonyl group, which are arranged in the axis of the bipyramid, and by five other ligands that are in one plane [9,10].

The calcium ion in myeloperoxidase affects the position of the distal histidine relative to the heme group iron and thus affects the microenvironment and catalytic activity of the enzyme. The oxygen atom of the hydroxyl group of the Ser174 residue and the oxygen atom of the Phe170 carboxyl group of the polypeptide chain are axial ligands, while the residues Asp96 (carboxyl oxygen and peptide carbonyl oxygen), Thr168 (hydroxyl and peptide carbonyl oxygen) and Asp172 (carbonyl oxygen) are arranged approximately co-planar. Of these ligands, only Asp96, near the distal histidine (His95), is derived from a light polypeptide chain. The histidine 95α-light subunit helix is distal and regulates enzyme activity. The distal histidine plays an essential role as an acid-base catalyst that is involved in oxygen–oxygen (O–O) bond heterolysis in a hydrogen peroxide molecule by regulating deprotonation of peroxide and protonation of the resulting water molecule. The presence of calcium ions that maintain the correct orientation of the distal histidine and play a role in the interaction between the light and heavy dimer subunits is a characteristic of all mammalian peroxidases [9,10].

Properties of myeloperoxidase

The myeloperoxidase enzyme has two activities: chlorinating and peroxidative (Figure 2).

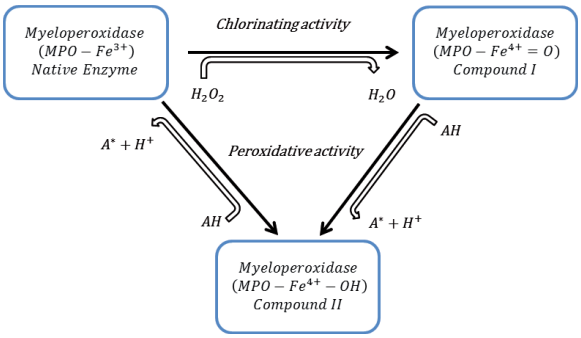

Figure 2. Enzymatic cycle of myeloperoxidase

This chlorinating activity has been very well described and reported in four of the scientific articles (Malle et al., Davies et al., Ikeda-Saito et al., and Kettle et al.) included in this review. This activity is based on the catalytic oxidation by myeloperoxidase of chloride (Cl^-), bromide (Br^-), or thiocyanate (SCN^-) ions to the appropriate halide (HXO, HOCl, or HOBr) or thiocyanate (HOSCN) in the presence of hydrogen peroxide.

$$H_2O_2 + X^- \longrightarrow HOX + H_2O$$

The appropriate halide acids or thiocyanic acid (HXO/HOSCN) formed during these reactions can then participate in further non-enzymatic reactions, such as oxidation and chlorination of chemical compounds present in their immediate environment. The most important task that arises during the acid chlorination reaction is protection of the body against the action of microorganisms because these compounds

are highly toxic to bacterial cells. Normally, to measure chlorinating activity, a reaction using chlorination of monochlorodimedone to dichlorodimedone, or reaction with taurine, in which taurine chloramine is formed, is used (Figure 3). During these reactions, product formation or substrate consumption can be monitored with a spectrophotometer [6,7,11,12].

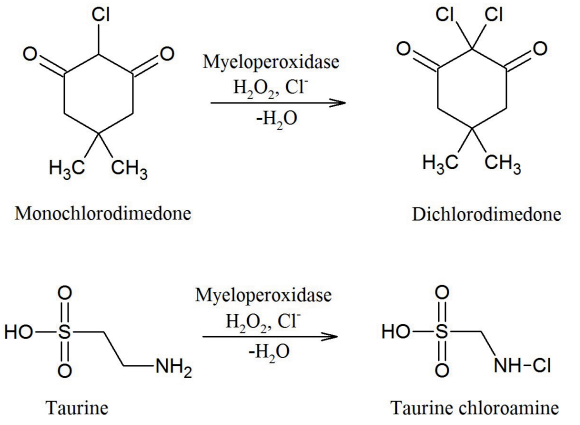

Figure 3. Oxidation of monochlorodimedone and taurine by myeloperoxidase

Peroxidative activity was described in three of the scientific articles (Malle et al. 2007, Davies et al. 2010, and Furtmüller et al. 2006) included in this review. This activity consists of myeloperoxidase catalysis of a one-electron oxidation reaction of a typical AH_2 peroxidase substrate with hydrogen peroxide to the appropriate radical (AH*).

$$H_2O_2 + 2AH_2 \longrightarrow 2AH^* + 2H_2O$$

During the reaction of the native form of the enzyme (*Por* – Fe^{3+}), the iron ion in myeloperoxidase is in the third degree of oxidation. In the resulting Complex I, the iron is in the fourth degree of oxidation and contains the cationic porphyrin radical ($Por^{\bullet+}$ – Fe^{4+} = 0). Complex I myeloperoxidase is a powerful oxidant that oxidizes both mono- and bi-electron reactions. This complex can oxidize many different substrates, including tyrosine, tryptophan, phenol, indole derivatives, hydrogen peroxide, and xenobiotics. Complex I can be reduced to the native form of the enzyme by reaction with halide ions (chlorination activity) to the corresponding halide acids or form Complex II (*Por* – Fe^{4+} – OH). Complex II iron is in oxidation state 4, and the bond between iron and oxygen is extended. This complex is formed as a result of the first one-electron reaction with the first substrate molecule (AH_2) and the substrate radical cation (AH*). Complex II can be reduced by the second substrate molecule back to the native form of myeloperoxidase or may form Complex III, with the iron ion in oxidation state 3 ($Por^{\bullet+}$ – Fe^{3+} – $O_2^{\bullet}$). This complex is formed as a result of the reaction of Complex II with an excess of hydrogen peroxide or by the reaction of Complex I with a superoxide ion [6,7,9]. Normally, to measure peroxidative activity, the reaction of o-dianisidine to oxidized o-dianisidine is used (Figure 4).

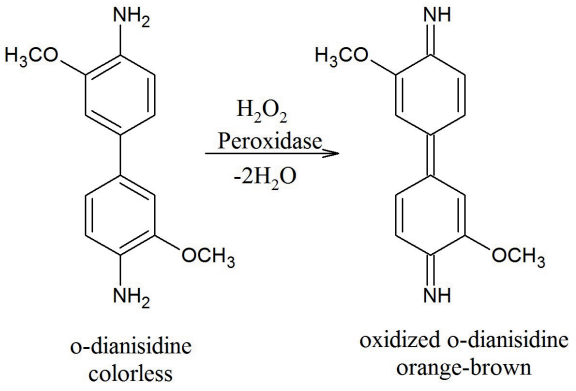

Figure 4. Oxidation of o-dianisidine by myeloperoxidase

Role of myeloperoxidase in carcinogenesis

Malle et al. reported that myeloperoxidase is a cytotoxic and bactericidal protein secreted by neutrophils at inflammatory sites that protects the body against various pathogens by generating HOCl (Figure 5) [6].

Klebanoff characterized myeloperoxidase as one of the main enzymes secreted by neutrophils as a result of phagocytosis during an inflammatory reaction; thus, it serves as an immunohistochemical marker for neutrophils [13]. Khan et al. submitted that an increase in the concentration of myeloperoxidase in plasma and other body fluids in humans may be useful as a marker during several inflammatory diseases, including rheumatoid arthritis, septic shock, atherosclerosis, renal disease, lung injury, and multiple sclerosis [14].

On the other hand, Atwal et al. and Ikwegbue et al. determined that HOCl (a powerful antimicrobial agent) can damage DNA, proteins, and fats and can oxidize fats by generating chloramine, nitrating agents, and free radicals. Myeloperoxidase catalyzes the production of HOCl, which causes damage to the DNA (Figure 5) molecule and can lead to mutations in oncogenes. The identification of defects in the DNA of 5-chlorocytosine (5-CIC) caused by secreted HOCl to inactivate or kill microorganisms through toll-like receptor 4 (TLR4) can cause chronic inflammation in the intestines, becoming evidence linking inflammation directly to cancer [15,16].

The work of Zhu et al., Qin et al., and Cascorbi indicates that myeloperoxidase expression disorders and an increased risk of various cancers may be directly related to myeloperoxidase gene polymorphisms. Many epidemiological studies have shown

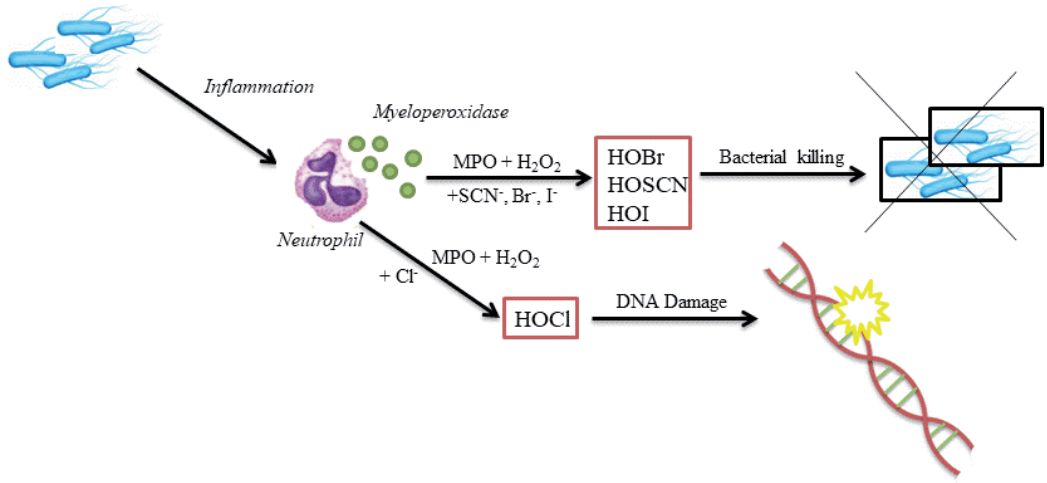

Figure 5. The role of myeloperoxidase in damage of the DNA molecule as a result of inflammation, leading to mutations

that the MPO G-463A polymorphism has an impact on the risk of many cancers, including lung cancer, breast cancer, bladder cancer, lymphoma, esophageal cancer, hepatocellular carcinoma, and laryngeal cancer [17–19]. Feyler et al. revealed that single nucleotide polymorphisms in the myeloperoxidase gene promoter region can affect protein transcription and expression [20]. Nauseef demonstrated that the replacement of thymidine with cytosine in codon 569 results in the substitution of an amino acid from arginine to tryptophan, which can cause functional defects in myeloperoxidase [8].

One of the studies in the review (Stevens et al.) showed that myeloperoxidase can also induce cancer indirectly by activating genotoxic intermediates and procarcinogens. As a result of the metabolism of certain unsaturated fats and amino acids (e.g., serine and threonine), it can form by-products, such as acrolein, which in turn form protein acrolein adducts. The main endogenous sources of acrolein are myeloperoxidase-mediated degradation of threonine and amine oxidase-mediated degradation of spermine and spermidine. In situations of oxidative stress and inflammation, they may be a significant source of acrolein. The biological effects of acrolein are a consequence of its reactivity toward biological nucleophiles, such as guanine in DNA and histidine, arginine, lysine, and cysteine residues in critical regions of proteases, nuclear factors, and other proteins. The resulting acrolein adducts may impair the function of these macromolecules, which can cause mutations, lesions in the transcriptome, and apoptosis modulation [21]. Tang et al. reported that the free form of acrolein induces α- and γ-hydroxy-1,N2-cyclic propano-2′-deoxyguanosine (α-OH-Acr-dG and γ-OH- Acr-dG) adducts in human cells. It was found that both types of Acr-dG adducts could be mutagenic and that they may induce G to T and G to A mutations [22]. For example, Tsou et al. introduced the concept that the mapping of the Acr-dG adduct distribution at the nucleotide level in acrolein-treated normal human bronchial epithelial cells determined that the acrolein-DNA binding spectrum in the p53 gene coincides with the p53 mutational spectrum in cigarette smoking-related lung cancer [23].

Role of tumor-associated neutrophils in cancers

According to Fridlender et al., tumor-associated neutrophils (TANs) are defined as neutrophils that have migrated into tumors [24]. TANs were found to be independent prognostic factors for overall survival, recurrence-free survival, and cancer-specific survival in localized clear cell renal carcinoma [25]. TANs had a predominantly immunosuppressive function in renal cell carcinoma, and the presence of TANs was an independent, unfavorable prognostic factor in patients treated with immunotherapy and tyrosine kinase inhibitors [26]. TANs were also found to be a prognostic factor in head and neck squamous cell carcinoma [27] and lung cancer [28]. Infiltration of neutrophils was found to correlate with tumor grade in human gliomas [29] and to be related to more aggressive types of pancreatic tumors [30].

A meta-analysis (Shen et al.) of 20 studies (including 3,946 patients with various solid tumors) investigating the presence of TANs in different cancer types found that a high density of tumor-infiltrating neutrophils was associated with unfavorable survival, recurrence-free survival/disease-free survival, cancer-specific survival, and overall survival. Conversely, peritumoral and stromal neutrophils were not statistically significantly associated with survival [31].

In analyzing the results of studies regarding the significance of TANs, two existing phenotypes of these cells present in tumors should be considered.

Under the influence of cytokines, TANs undergo polarization into either a protumorigenic (N2) phenotype or a proinflammatory/antitumorigenic (N1) phenotype. Polarization toward the N2 phenotype depends on transforming growth factor β (TGF-β), while TGF-β blockade leads to the recruitment and activation of the antitumorigenic N1 phenotype [32]. Antitumorigenic (N1) inflammatory neutrophils produce more reactive oxygen species (ROS) and higher levels of nitric oxide, hydrogen peroxide, and tumor necrosis factor alpha (TNF-α) than N2 TANs [33]. The N1 TAN phenotype can also recruit and activate CD8+ T cells, which are key contributors to any tumor immune response, while N2 TANs inhibit the function of CD8+ T cells [32].

In subset univariate analyses, infiltration by MPO-positive cells was associated with significantly longer overall survival in the triple-negative breast cancer subtype, the HER2-enriched subtype, and the luminal B/HER2-negative subtype. The expression of MPO-positive neutrophils in tumors showed that it is an independent prognostic factor for improved overall survival in multivariate analysis [34].

A study of a population of 334 patients attempted to explain the role of TANS in ovarian cancer. Analysis of this group of patients determined that neutrophils infiltrating tumors were found in 72% of cases. Co-cultivation of ovarian cancer cells with either neutrophils or neutrophil lysate can cause a change in the polygonal epithelial phenotype of these cells to the spindle morphology, resulting in cribriform cell growth. The reason for these changes in the shape of cells caused by neutrophils may be elastase, which is one of the most important proteases released by these cells. The change in shape induced by elastase is most likely due to degradation of membranous E-cadherin, which leads to loss of cell contact and polarization [35]. Moreover, in response to elastase, epithelial cytokeratins were downmodulated in parallel with nuclear translocation of β-catenin. These neutrophil elastase-induced alterations in cancer cells were compatible with the epithelial-to-mesenchymal transition (EMT) phenomenon. Following EMT, the cells displayed a more migratory phenotype. Neutrophil infiltrates were detected preferentially in areas with low E-cadherin expression. These *in vitro* data established a link between neutrophil-derived elastase, loss of E-cadherin, and EMT, which may explain why ovarian cancer patients with increased levels of neutrophils in tumors have a poorer prognosis [35].

Myeloperoxidase in ovarian cancer

We included five studies in this review to present the importance of myeloperoxidase in ovarian cancer [36–40].

In experimental studies by Saed et al., myeloperoxidase was expressed in ovarian cancer cell lines. In addition, it was observed in invasive ovarian cancer cases but not in normal ovarian epithelium. By causing caspase-3 nitrosylation, myeloperoxidase may inhibit apoptosis and increase ovarian cancer cell survival. In turn, silencing myeloperoxidase can significantly induce apoptosis, which underlines its role as a redox switch that regulates apoptosis in ovarian cancer [5]. Myeloperoxidase expression was evaluated in a study by Fletcher et al., who found significantly higher levels of myeloperoxidase expression in ovarian cancer tissues compared with benign and inflammatory lesions. International Federation of Gynecology and Obstetrics (FIGO) stages II–IV ovarian cancers manifested higher levels of tissue myeloperoxidase than FIGO stage I ovarian cancers ($p<0.05$). Also, ovarian cancer stages II–IV had significantly higher levels of serum myeloperoxidase compared with early-stage ovarian cancer, control, benign, and inflammatory groups. Serum myeloperoxidase levels assessed in FIGO stage I ovarian cancer and gynecological inflammation disorders did not differ significantly from each other but were significantly different from the control group and benign ovarian lesions [36].

One of the first studies (Olson et al.) assessing polymorphisms of the MPO gene in patients with ovarian cancer found that lower expression of the A allele (GA/AA) genotypes was associated with a small reduction in risk (OR=0.72); however, this trend did not reach statistical significance. The authors postulated the hypothesis that for myeloperoxidase, the slightly reduced risk for women with the AA genotype at position –463 in the promoter region could be protective, because this leads to weakening of the binding site [37]. Another study assessing myeloperoxidase polymorphisms by Castillo-Tong et al. showed that the higher expressing -463GG genotype was more frequent in FIGO I early-stage carcinoma. This suggests that the G allele increases the risk of ovarian cancer. Together, these studies suggest that atypical expression of this normally myeloid-specific MPO gene can cause oxidative damage and accumulation of potentially pathogenic mutations in ovarian epithelial cells that increase the risk of cancer. The GG genotype usually leading to higher expression of myeloperoxidase was not overrepresented in more advanced FIGO stages II–IV of ovarian carcinoma. A possible explanation for these findings is that myeloperoxidase expression in early-stage GG genotype carcinomas causes oxidative damage that shortens cell survival so that fewer GG genotype cancer cells survive to advanced stages. Another possibility is that higher levels of myeloperoxidase in infiltrating cancer cells with the GG genotype by neutrophils and monocytes/macrophages could enhance the killing of

cancer cells at an early stage of development, which could reduce the number of GG genotype cases detected in FIGO stages II–IV [38].

An investigation of the predictive role of myeloperoxidase and interleukin (IL)-17 in chemotherapy in ovarian cancer patients conducted by Droeser et al. revealed that IL-17- and MPO-positive immune cells correlated with each other in the tissues of both primary and recurrent carcinomas. Myeloperoxidase expression in multivariate Cox regression analysis combined categorized IL-17 and myeloperoxidase cell densities in ovarian cancer primary tumor tissues, indicating that the combination of these two immunological biomarkers was an independent prognostic factor for relapse-free survival. In the subgroup of IL-17- and MPO-positive biopsies of primary and recurrent cancer patients, there were no chemoresistant patients [39].

Dai et al. stated that myeloperoxidase has been used to produce modern nanoparticles to improve the effectiveness of platinum analogues, which are crucial in the treatment of ovarian cancer patients. In order to improve the therapeutic efficacy of platinum analogues, the idea of HOCl production *in situ* was used in experimental studies. Modern nanoparticles have been developed in which the phagocytic enzyme myeloperoxidase is coated with two functional polyphenol derivatives (PEG polyphenols and platinum prodrug polyphenols) and a ferric ion by metal phenolic coordination, which can shield myeloperoxidase from degradation by other compounds in the blood. Additionally, in cells, the platinum prodrug may be reduced to cisplatin and produce hydrogen peroxide. In the intercellular environment, myeloperoxidase may catalyze the conversion of hydrogen peroxide to HOCl. The preparation of MPO Pt PEG nanoparticles (MPP NPs) may be employed as an ROS cascade bioreaction to enhance platinum analogue therapy. It was found that treatment with MPP NPs caused significantly higher antitumor activity than free cisplatin at the same dose. Mice treated with MPP NPs exhibited much longer survival. Moreover, hematoxylin and eosin staining of tumor sections from MPP NPs showed the most significant tumor cell apoptosis and necrosis compared with the control groups. It was evidenced by ^{89}Zr-based positron emission tomography imaging that MPP NPs could circulate for a prolonged time in the blood and showed high accumulation in tumors. No change in body weight was observed during any treatment. Furthermore, analysis of the major organs (lung, liver, spleen, heart, and kidneys) determined that there were no significant histological changes [40].

Conclusions

Since ovarian cancer is one of the most common cancers in women, it is imperative to refine methods to detect it earlier. Because myeloperoxidase oxidizes many different compounds, including halogenated ones, it causes DNA damage, thus increasing the risk of mutations that cause an increase in ovarian cancer. Therefore, continuous research on the expression of myeloperoxidase in ovarian cells is vital and warranted.

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ACUTE POISONING AMONG CHILDREN AND ADOLESCENTS: A NARRATIVE REVIEW

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Acute poisoning is a frequent emergency and a significant health concern in the pediatric population. The pattern of acute intoxication differs between countries and within each country. Poisoning depends on many factors. It can be divided into two categories (accidental and intentional), and each one has its own characteristics.

Aim of the study: This study aimed to analyze and discuss the overall patterns of accidental and intentional poisoning among children and adolescents.

Material and methods: A systematic literature search was conducted using Google Scholar, Elsevier, and the PubMed database. The following keywords were used: "acute poisoning", "pediatric poisoning", "intentional poisonings", "unintentional poisonings", and "suicide attempts".

Results: A total of 38 articles were included in the review. Half had been published in the last five years. The analysis focused on the characteristics of the materials and methods, results, and conclusions sections of each study.

Conclusions: Unintentional poisonings dominate among younger children, with a slight male predominance. They usually occur at home and occasionally lead to severe harm or even death. The most common causes of intoxication in this population are medications and household products. The majority of poisonings among adolescents are intentional suicide attempts. Among older children, over-the-counter analgesics are the most common cause of acute poisoning. Accidental poisoning can be avoided by providing preventive educational programs to guardians and replacing potentially toxic household products with safer ones. The prevention of intentional poisoning should be based on a community support system and behavioral programs. Healthcare professionals should be familiar with poisoning and be aware of the different patterns of intoxication according to age and gender.

KEYWORDS: poison, poisoning, suicide attempt, emergency department, toxicology

Background

Acute poisoning is defined as acute exposure to a toxic substance. This substance can be ingested, injected, inhaled, or absorbed through the skin's surface [1]. Pediatric poisoning is a common health issue and an important public health concern; it is the fifth leading cause of death in children under five [2]. Poisoning patterns vary between countries and even within each country. They are affected by several factors, including geography, socioeconomic factors, culture, and religion [3]. According to a Polish study that was conducted from 2009 to 2011, the overall number of hospitalizations due to poisoning decreased slightly. However, poisoning remained a significant cause of death in certain groups. Patients in the 11–18-year-old age group were the largest group admitted (30,546 cases) [4].

Poisoning is divided into two main categories (accidental and nonaccidental) in terms of cause and intention. In some cases, the intent is undetermined [5]. Unintentional poisoning is observed mostly

among infants and children under five years of age, and they usually occur at home [6, 7]. Intentional poisoning is more common in teenagers and adults and is usually a suicide attempt [3, 8].

The etiology of poisoning differs according to many factors, including availability of drugs/toxic substances, cultural background, and economic condition of the country [4]. Accidental poisonings occasionally lead to severe harm or even the death of the child. Most substances kept at home are nontoxic or minimally toxic [7]. In older age groups (school children and adolescents), substances such as over-the-counter analgesics, antidepressants, antihistamines, antipsychotics, and narcotics [6] are the main causes of poisoning. These substances are responsible for the highest number of serious medical outcomes [9].

Aim of the study

This study aimed to analyze and discuss the overall patterns of acute poisoning among children and adolescents. Both accidental and intentional poisonings were subjects of interest. Attention was directed to the prevention and management of poisoning as a difficult and debatable topic.

Material and methods

A systematic literature search was conducted using Google Scholar, Elsevier, and the PubMed database (Figure 1). The following keywords were used: "acute poisoning", "pediatric poisoning", "intentional poisonings", "unintentional poisonings", "suicide attempts", "acute poisoning prevention", and "acute poisoning management". A total of 38 publications were included in the review. Half had been published in the last five years. Articles from earlier years were included because of the low number of more recent acute poisoning reports among children and adolescents. They contained key information not available anywhere else.

Results

Accidental poisoning

According to Lee et al., accidental poisonings occur mostly in young children through ingestion of a single substance. They usually happen at home from 6 p.m. to 12 a.m. In the group of children younger than five years old, 71.2% of the cases were unintentional [6]. Another [7] pointed out that the

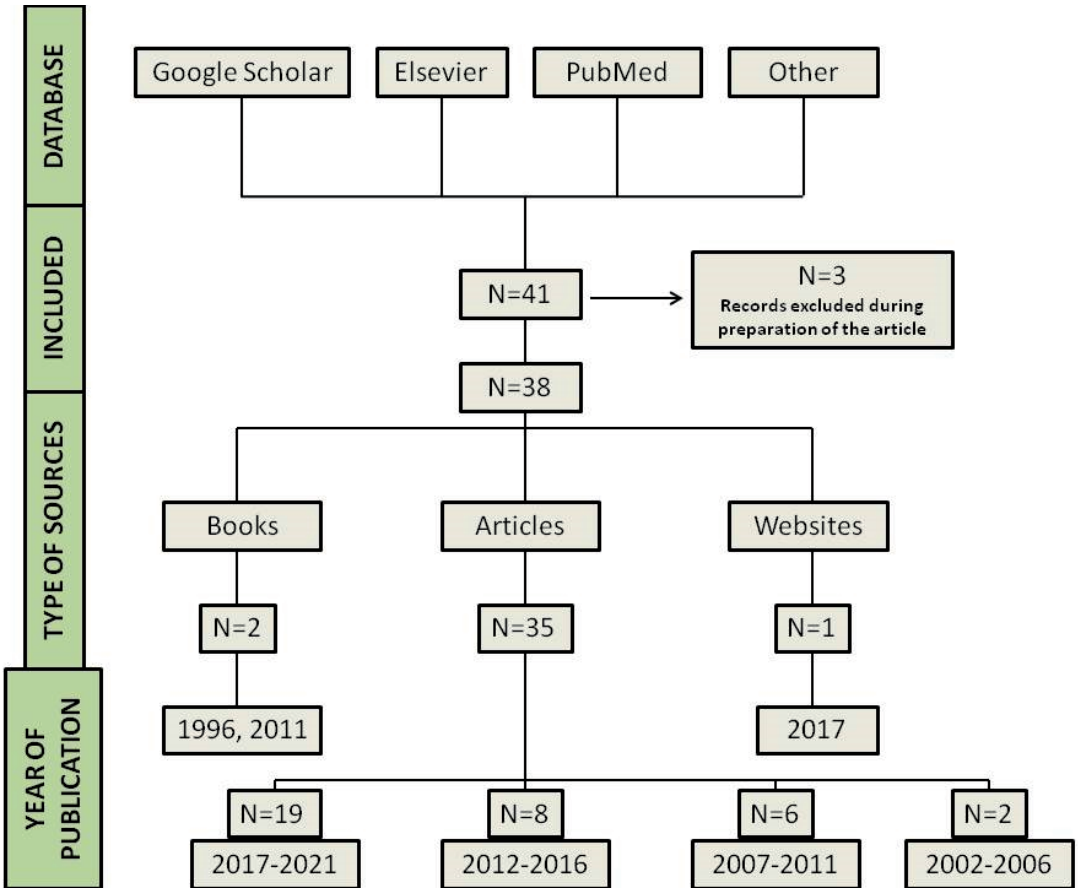

Figure 1. Characteristics of sources

Table 1. Detailed characteristics of the included articles

Authors	Publication year	Type of study	Number of cases	Accidental or intentional poisoning	Most common causes of intoxication
Lee et al.	2019	Retrospective descriptive study	590	Accidental, intentional	Medications
Anderson et al.	2016	Retrospective descriptive study	201	Accidental, intentional	Medications (methadone)
Kierus et al.	2011	Retrospective descriptive study	305	Accidental, intentional	Medications
Hermanns-Clausen et al.	2019	Retrospective descriptive study	42,344	Accidental	Fruit of poisonous plants (yew tree, cherry laurel, rowanberry)
Pac-Kożuchowska et al.	2016	Retrospective descriptive study	848	Accidental, intentional	Improperly stored medications, household chemicals, alcohol, narcotics.
Sheridan et al.	2017	Retrospective observational study	390,560	Intentional	Ibuprofen, acetaminophen, selective serotonin reuptake inhibitors
Tay et al.	2021	Retrospective descriptive study	87	Intentional	Medications
Gonzalez-Urdiales et al.	2021	Retrospective, cross-sectional study	1,688	Intentional	Medications (mainly psychotropics and analgesics)
Vilaça et al.	2019	Retrospective, cross-sectional study	353	Accidental	Medications , cleaning products
Akbari et al.	2021	Descriptive cross-sectional study	424	Accidental, intentional	Narcotics, stimulants, alcohol

rate of deaths caused by accidental exposures has decreased slightly in recent years. However, there was a reverse tendency in nonaccidental cases. Male patients were predominant in the age group younger than 11 years old. More than 90% of the cases occurred at home. Children under six years old were poisoned with pharmaceutical drugs in 50% of cases. The other 50% of intoxications were caused by non-drug substances, such as cosmetics, cleaning solutions, personal care items, foreign objects, and plants [7]. Accidental poisoning among children is a common health concern, but cases with severe or fatal outcomes are rare. In the United Kingdom between 2001 and 2013, 28 deaths were registered as due to unintentional poisoning in children aged four or less. Methadone was the cause in 16 cases. In the other cases, tricyclic antidepressants, heroin, iron and its compounds, other opioids, hydantoin derivatives, and synthetic narcotics were responsible for the children's deaths [10].

According to a study by Hermanns-Clausen et al., accidental poisoning with plants like, for example, liguster, lily of the valley, or mahony was the most common cause in children aged 0.5–5 years. It was mainly oral ingestion (98%) and involved fruits of yew tree, cherry laurel, and rowanberry among others, in 60% of cases. In most cases, poisoning remains asymptomatic [11]. In the United States in 2016, children aged 1–17 years old were the predominant group of patients admitted to emergency departments due to ingestion of poisonous mushrooms (41.3% of cases). It should be noted that in some cases, the exposure was intentional. Ten percent of patients older than five years old consumed mushrooms for hallucinogenic purposes [12].

In a Polish study [13], 305 cases of acute poisoning among children were registered between 2006 and 2010. The minority were accidental (31.1%). Children aged 3–4 years old (with no gender difference) and living in urban areas were most likely to experience accidental intoxication. The most common causes were analgesics, antipyretics, cardiac medications, sedatives, and detergents. The general condition on admission was usually good or very good [13].

Another Polish study [14] revealed differences in the patterns of acute poisoning among children in urban and rural areas. It reported that in the studied areas , the five-year-old and under age group made up the highest proportion (39,7%). More cases were from urban areas (64.5%). Accidental poisonings were observed more frequently (56%) and occurred in both urban and rural areas. The frequency of accidental poisoning decreased with the age of the children. There was a male predominance of urban children in cases of unintentional poisoning only. In rural areas, accidental poisoning was equally common in males and females. Household products have been reported to be the most common cause of accidental exposure. Children aged five and under from rural areas were more likely to be poisoned with household products, such as corrosive substances, solvents, fuels, oils, and pesticides [14].

A summary of the issues presented above is depicted in Figure 2.

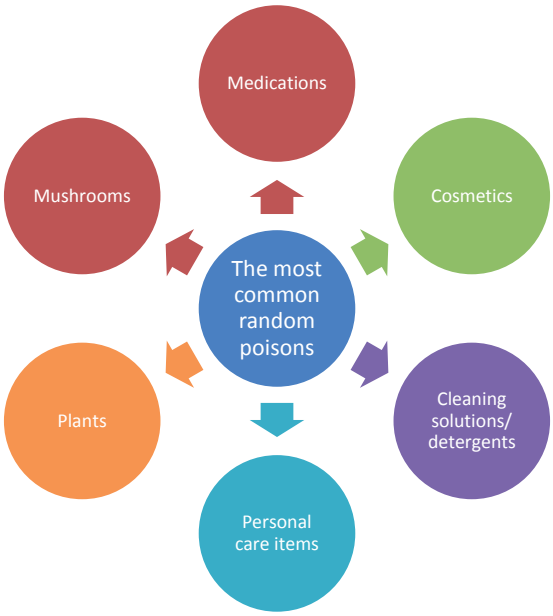

Figure 2. The most common causes of accidental poisoning in children

Intentional poisoning

Suicide is a serious global health problem. According to the World Health Organization (WHO), suicide is the leading cause of death in children aged 10–19 years old in low- and middle-income countries. Suicide is the second leading cause of death in high-income countries in the European Region [15]. The most common suicide method in the world is hanging, followed by pesticide poisoning for women and gunshots for men [16]. Suicide is not the only problem, because behind every suicide, there are many suicide attempts. According to the WHO, a suicide attempt is a very important risk factor for suicide in the general population [17].

The deliberate ingestion of poisonous substances is generally observed in older children and adolescents [8]. Poisoning is associated with a relatively low mortality rate compared to other methods of suicide. Due to this fact, females are the predominant group to use this method, mostly because they want to draw the attention of their community to their problems [8, 18]. Suicide attempts due to poisoning are most often committed by children aged 14–18 years old [8].

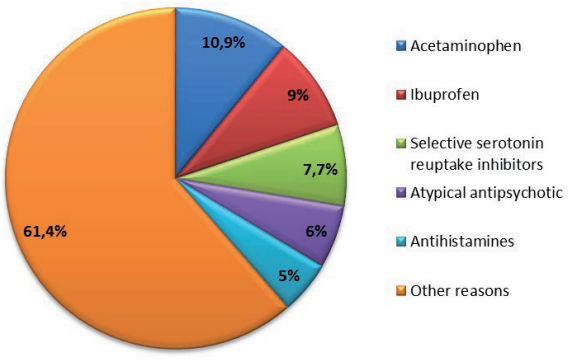

Figure 3. Substances most often consumed by children and adolescents for suicide purposes. Based on Sheridan's "Adolescent Suicidal Ingestion: National Trends Over a Decade" [19]

Sheridan et al. published a study describing 13–19-year-olds who consumed poisonous substances between 2004 and 2013 to "deliberately attempt suicide" [19]. In the United States, there were 390,560 reports of suicidal poisoning during the 10-year study period, 80,3% of these cases were adolescents. Adolescents most frequently took acetaminophen (10.9%), ibuprofen (9%), selective serotonin reuptake inhibitors (7.7%), atypical antipsychotics (6%), and antihistamines (5%) (Figure 3). They found that severe clinical outcomes or death were most often caused by antidepressants and atypical antipsychotics.

A 2019 study found that intentional poisoning occurred most often in teenage females. Consumption of pharmaceuticals was the main cause of poisoning [6].

In 2021, Tay et al. published the results of an analysis of collected poisoning cases in the pediatric ward between January 2014 and December 2015 [20]. Among 87 cases of intentional poisoning, 31 (35.6%) had suicidal intentions. The main demographics were females (85.1%) and adolescents over 16 years of age (93.1%). There was a psychiatric history in 57.5% of the cases, and 62 patients (71.3%) had self-harmed in the past. Twenty-seven patients (31%) had a history of intentional poisoning, and 15 patients (17.2%) had other intoxication episodes. Deliberate overdose of regularly administered medications was observed in 15 (35.7%) of the 42 patients taking medication. Notably, 12 (80%) of those 15 cases were psychiatric medications.

A multicenter study of childhood poisonings from 105 emergency departments included 1,688 cases [21]. Among the reported cases, deliberate poisoning was found in 233 patients (13.8%). The female-to-male ratio was 4.7:1, and most of the incidents occurred in the patient's home. The most common toxins ingested by the patients were pharmaceutical drugs, mainly psychotropic and analgesic medications. Ninety patients (38.6%) reported a previous episode of intentional poisoning. There were no deaths in the study group.

Discussion

Both accidental and intentional poisonings have their own patterns and characteristics. Most cases of accidental poisoning are potentially avoidable. Therefore, more public attention should be given to educating and informing caregivers about the im-

portance of properly storing household products, medications, and other potentially toxic substances. Pediatricians and emergency department staff should be familiar with the management of acute poisoning and be aware of the different agents of intoxication according to age and gender. This knowledge enables them to be better prepared in the event of pediatric poisoning, reducing the time needed to make proper therapeutic decisions. Additionally, this information allows public health authorities to focus on poison prevention.

How can poisoning be prevented among children?

The prevention of poisoning among children and adolescents is challenging in many respects. Poison prevention education programs (including free or low-cost poison control stickers and locks for drawers/cupboards) have been proven to increase the level of protection around dangerous substances in people's homes. Despite existing evidence that educational programs can improve safety-related behavior, it is unclear whether they lead to fewer accidental poisonings [22, 23]. Parents and caregivers should be alerted that they have to be prepared to immediately contact a healthcare professional when a potential poisoning occurs. The United Nations Children's Fund and the WHO recommend replacing potentially toxic household products with similar products that are safer. Such management could prevent poisoning in children and limit subsequent negative health outcomes [24, 25].

An example of prophylaxis against intentional poisoning is mitigating the risk factors for suicide. A suicide attempt is usually the result of a long-term build-up of problems and fears. Such interventions for children from risk groups include cognitive behavioral therapy programs. The following should be involved in preventive activities: family, school, healthcare system, police, and state administration [8]. An important action that can prevent deliberate poisoning is limiting the access of children and adolescents to the most common methods of suicide and to the most common risk factors, such as alcohol, drugs, and the Internet. The problem of intentional poisoning among children is an interdisciplinary issue that should be solved by many people, including pediatricians, psychologists, teachers, child psychiatrists, and parents.

Management of acute poisoning

The management of acute poisoning is a complex and sometimes controversial health issue. It consists of decontamination, elimination, antidotes, symptomatic treatment, and supportive care [26]. Decontamination of the gastrointestinal tract has been attempted for decades using induced vomiting, gastric lavage, and activated charcoal [27]. The use of gastric lavage for decontamination is controversial. There are studies showing that it should not be used routinely; it should only be considered in rare cases [28, 29]. One example when gastric lavage is highly recommended is after poisoning with *Amanita phalloides* (a fatal fungus), especially within the first hour after ingestion [30]. Activated charcoal, which is on the WHO Model List of Essential Medicines [31], plays a major role in detoxification. It absorbs many substances, including medications, phytotoxins, and chemicals. However, it is ineffective in cases of poisoning with acids, bases, alcohols, solvents, inorganic salts, and metals [32]. Charcoal should be administered as soon as possible, preferably within the first hour after ingestion. The duration of administration can be extended with slowly absorbed substances [33]. The adequate dosage is 10 [34] to 40 [33] times as much as the amount of ingested poison, or 0.5–1.0 g/kg body weight in children [32].

Antidotes play a significant role in the treatment of poisoned patients. Some antidotes should always be present in emergency departments, while others should be available within one hour [35]. Acetaminophen is one of the most common causes of drug poisoning and overdose. The treatment of these poisonings is based on the administration of activated charcoal and a specific antidote (intravenous acetylcysteine) at a total dosage of 300 mg/kg [36]. Acetylcysteine is also part of the treatment of *Amanita* mushroom poisonings [37]. A patient presenting with a life-threatening toxidrome or in a severe condition who requires advanced life-saving therapies should be treated in an intensive care unit [38].

Limitations

First, it should be mentioned that although acute poisoning is a significant health concern, no nationwide registry of poisonings has been created in Poland, which results in a lack of accurate data. Only a few recent articles have been published concerning the subject of pediatric poisoning in Poland. Additionally, the original papers concerning this subject are usually single-center studies. Therefore, further investigation and more recent data are required.

Conclusions

Pediatric poisoning is a common emergency and a significant health concern. The pattern of poison-

ing is different in each country and region, but there are some similarities. Accidental poisonings occur at home, among younger children, with a slight male predominance, and due to ingestion of household products or pharmaceutical drugs. These poisonings are usually the result of their caregivers being careless. Intentional poisoning occurs most often among older children and adolescents. They are often the result of suicidal behavior.

Ethics

The authors had full access to the data and take full responsibility for its integrity.

All authors have read and agreed with the content of the manuscript as written.

The study was conducted in accordance with the Declaration of Helsinki Declaration, EU Directives, and with the standards required by biomedical journals.

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Case reports

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INTUSSUSCEPTION AS A PRESENTATION OF BURKITT'S LYMPHOMA: A CASE SERIES

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Intussusception remains one of the most common emergencies in pediatrics. It typically occurs between six months and three years of age, but it can be observed in all age groups. Intussusception usually presents with traditionally described symptoms; however, it is believed that the older the patient, the higher the risk of an existing pathological lead point, which could be associated with less characteristic symptoms. It is crucial to make a timely diagnosis when intussusception is caused by a malignancy, such as Burkitt's lymphoma, as the treatment of limited-stage Burkitt's lymphoma has become very successful in recent years.

Aim of the study: The authors performed an analysis of all patients who presented to the clinic with intussusception caused by Burkitt's lymphoma to determine whether there are characteristic symptoms in this group of patients that would enable faster implementation of oncological diagnostics.

Case series: Four patients with an average age of eight years presented with intussusception as the first sign of Burkitt's lymphoma. They usually presented with a history of recurrent abdominal pain lasting for a few weeks. In three cases, a pathological lead point was visualized during the initial ultrasound examination. All of the patients were treated surgically. The stage of disease ranged from I to III, according to the St. Jude staging system.

Conclusions: Based on our small group of patients, we were able to observe some characteristic symptoms that are different from those most commonly seen in spontaneous intussusception: several weeks of recurrent abdominal pain, nausea, and vomiting. These observations are consistent with the spectrum and frequency of symptoms reported in the literature. The presence of a constellation of specific clinical features should allow clinicians to immediately suspect neoplastic diseases.

KEYWORDS: intussusception, Burkitt lymphoma, pediatric oncology, pediatric surgery, case report

Background

Intussusception remains one of the most common emergencies in pediatrics and the most common cause of intestinal obstruction in patients between six months and three years of age. Traditionally described symptoms include intermittent abdominal pain, red currant jelly stool, and a palpable abdominal mass in the right iliac fossa. The most common symptoms reported in the literature are intermittent progressive abdominal pain with sudden onset, vomiting, and bloody stools [1–4]. Although the majority of patients presenting with intussusception are younger than three years of age, it can occur in all age groups. It is believed that the older the patient, the higher the risk of an existing pathological lead point [5]. Moreover, in many cases, the symptoms observed in older patients differ from those characteristically and are most often observed in typical cases of intussusception. One possible pathological lead point is intra-abdominal non-Hodgkin's lymphoma (NHL), especially Burkitt's lymphoma. Although it rarely occurs as the cause of intussusception, it is crucial to diagnose this highly malignant and aggressive neoplastic disease as early as possible because the treatment of limited-stage Burkitt's lymphomas has become

very successful in recent years, with a long-term survival rate of over 90% [3, 6].

Aim of the study

The primary goal of the study was to analyze cases of intussusception caused by Burkitt's lymphoma that were treated in the Medical University of Warsaw Pediatric Surgery Department t between 2010-2021 in terms of clinical features, presenting symptoms, and outcomes. Such an analysis may help determine whether there are characteristic symptoms in this group of patients that would enable faster implementation of oncologic diagnostics and treatment. A literature review regarding intussusception caused by Burkitt's lymphoma follows, and there is a comparison of the results with our clinical data.

Material and methods

Data were collected from the hospital's internal database with a retrospective review of patient medical records to identify patients diagnosed with both intussusception and Burkitt's lymphoma according to the International Classification of Diseases, Tenth Revision, diagnostic coding.

The records of four patients who were diagnosed with intussusception caused by Burkitt's lymphoma and treated from 2010 to 2021 were identified. Reviewing the cases, the authors specifically searched for symptoms before admission, relevant medical history, diagnostic imaging findings upon admission, course of surgical treatment, Burkitt's lymphoma classification, course of oncological treatment, complications, and outcomes.

Case report

Patient information

All four patients were male. The average age was eight years, and the ages ranged from four to 14. One patient suffered from von Willebrand disease type II, one had an inhalation allergy, and the other two had no comorbidities.

The most frequently reported symptom was abdominal pain. It occurred in all four patients, although only one reported pain of an intermittent and paroxysmal nature accompanied by peritoneal symptoms.

Clinical findings

Two patients presented with resistance and tenderness in the right iliac fossa during the physical examination. One patient had grossly bloody stool on rectal examination, and one provided a history of blood-stained and tarry stool, but the physical examination revealed no abnormalities. One patient presented with vomiting and diarrhea.

Timeline

The duration of symptoms before admission to the hospital was three weeks for two patients, two weeks for one, and six hours for one, for a mean duration of symptoms of 14 days.

Diagnostic assessment

According to the laboratory examination results, three of the four patients had leukocytosis (11.03 x 10^3/μL–15.55 x 10^3/μL), two of the patients had anemia (8.9 g/dL–9.9 g/dL), and all four patients had elevated neutrophil levels (7.6 x 10^3/μL–12.18 x 10^3/μL). C-reactive protein was within normal limits in all four patients. Lactate dehydrogenase was elevated (926 U/L) in only one patient.

All patients underwent ultrasound examinations at the beginning of the diagnostic process. Ultrasound revealed ileocecal intussusception in three patients and ileoileal intussusception in one patient. A pathological lead point was visualized during the initial ultrasound examination in three patients, and there was immediate suspicion of lymphoma in one patient. In one patient, possible lymphoma was identified on computed tomography, which was performed a few days after admission due to inconclusive ultrasound results.

Therapeutic interventions

All of the patients underwent surgical interventions because of the pathological lead points that were identified during the diagnostic process. Three patients underwent laparotomies, while one underwent minimally invasive laparoscopic surgery. In two cases, the pathological lead points were identified as tumors only intraoperatively. In all cases, resection of the affected fragment of the intestine was performed, and primary anastomosis was completed. The postoperative period was uneventful for all four patients (Figures 1 and 2).

All of the patients received a histopathologically confirmed diagnosis of Burkitt's lymphoma. Apart from one case, all of the resections were determined to be radical. All patients were assessed according to the St. Jude staging system: one patient was diagnosed with stage I, two with stage II, and one with

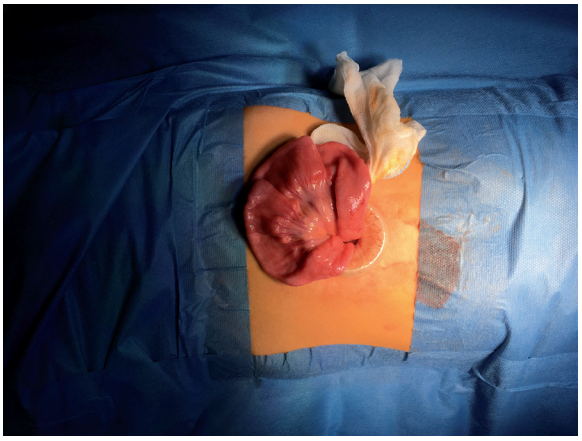

Figure 1. Intraoperative view of eventrated bowel loop. Single-port laparoscopic approach

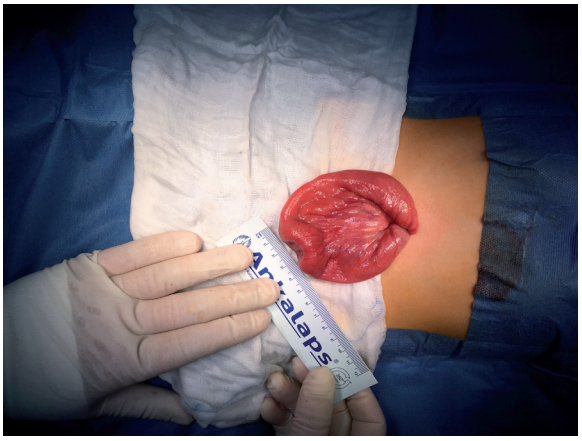

Figure 2. Intraoperative view of small bowel tumor after reduction of intussusception. Tumor diameter is approximately 5 cm

stage III, as the resection was not radical. None of the patients had central nervous system or bone marrow involvement.

Follow-up and outcomes

Two patients were treated with two COPAD regimens (cyclophosphamide, vincristine, prednisone, and doxorubicin). One patient was treated with COP prephase (cyclophosphamide, vincristine, and prednisone) and two COPADM regimens (cyclophosphamide, vincristine, prednisone, doxorubicin, and methotrexate). One patient was treated with COP prephase, two COPADM regimens, and two CYM regimens (cytarabine and methotrexate). The highest number of complications, which included infections, priapism, and febrile neutropenia, was observed in the case of the patient who received the greatest amount of chemotherapy. The average length of hospitalization was 27.75 days. During the follow-up period, which ranged from one to six years, three patients survived without relapses. In the case of the fourth patient, follow-up data were not found in the system.

The clinical data of the patients are summarized in Table 1.

Table 1. Patient characteristics

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4
Symptoms before admission	Abdominal pain and blood-stained stools for 2 weeks before admission	Paroxysmal pain lasting for a couple of hours with peritoneal symptoms	3 weeks of transient, paroxysmal abdominal pain in the navel area	3 weeks of abdominal pain, vomiting, diarrhea
Age and comorbidities	6 years old; von Willebrand disease type II	14 years old; inhalation allergy	4 years old; no comorbidities	8 years old; no comorbidities
Diagnostic imaging findings	Intussusception (ileocecal) visible on ultrasound, identification of the lead point, not suspected of neoplastic nature	Intussusception (ileocecal) visible on ultrasound, identification of leading point, tissue suspected of non-Hodgkin's lymphoma	Intussusception (ileocecal) visible on ultrasound, identification of leading point, not suspected of neoplastic nature	Intussusception (ileoileal), identification of leading point, suspected Meckel's diverticulum
Type and course of operation	Laparotomy after 2 days	Laparotomy on the day of admission	Laparotomy on the day of admission	Single port, hand-assisted surgery after 6 days
Disease stage (according to the St. Jude staging system)	II	II	III (resection not radical)	I
Outcomes	Hospitalization time: 36 days 6 years of follow-up with no relapses	Hospitalization time: 31 days 1 year of follow-up with no relapses	Hospitalization time: 22 days No follow-up data available after initial treatment	Hospitalization time: 22 days 1.5 years of follow-up with no relapses

Discussion

Intussusception caused by Burkitt's lymphoma is an uncommon condition, as Burkitt's lymphoma itself is a rare disease. The small size of the research sample is the main limitation of this analysis; for this reason, it was decided to extend the study to include a literature review on the subject to compare our results with a larger sample of patients.

The literature review was conducted by searching PubMed and Embase with the terms "Burkitt Lymphoma" and "Intussusception". The included studies described patients with intussusception confirmed to be caused by Burkitt's lymphoma along with their clinical features, symptoms, and outcomes. The focus was on describing patients with intra-abdominal, sporadic, non-HIV-related Burkitt's lymphoma.

The statistical data were processed using Microsoft Excel 365 (Microsoft Corporation, Redmond, WA, USA).

Forty-one articles out of 152 initially found in the databases were reviewed; they reported a total of 146 cases of intussusception confirmed to be caused by Burkitt's lymphoma. During the screening process, several articles describing intussusception caused by intra-abdominal lymphomas were excluded due to an inability to differentiate the cause of intussusception between Burkitt's lymphoma and other types of lymphoma.

The identified patients had an average age of 7.42 years, and there was a male predominance. The most common symptoms described were abdominal pain and vomiting, followed by blood in the stool and loss of appetite. It is worth mentioning that the characteristic "red currant jelly" stool was reported rather rarely. The mean duration of symptoms before admission to hospital was 38.35 days, with a range from three days to six months. However, it seems unlikely that the patient with the longest duration of symptoms in fact had Burkitt's lymphoma, as it is a very rapidly growing neoplasm. No characteristic abnormalities were found in the laboratory results. In the majority of cases in which the surgical procedure was described, the patients underwent segmental resection with primary anastomosis or hemicolectomy. In a few cases, only a biopsy was performed. Staging of the disease was reported in only approximately half of the cases, with the majority assessed as stage II. Reporting of treatment regimens and outcomes was very heterogeneous, and most studies did not report on those aspects; therefore, it is difficult to draw meaningful conclusions about these parameters. However, when the outcomes were reported, the majority of cases were described as relapse-free, with only two deaths reported.

In studies of groups of patients with Burkitt's lymphoma, the incidence of intussusception was estimated at an average of 30% (6.7%–66%), which is significantly higher than has been reported in other studies [7].

Despite the fact that Burkitt's lymphoma is a rare disease, it is the most common type of primary NHL of the gastrointestinal tract in children. It is vital to diagnose it correctly as early as possible and implement treatment promptly, as it is highly malignant and progresses very quickly [8]. Proper surgical treatment combined with chemotherapy raises the patient's chances of survival, although some studies suggest that surgery does not result in a significant difference in survival [6, 8]. Because of the increasing number of childhood cancers, including Burkitt's lymphoma, it is likely that the number of cases will rise in the future [9, 10].

Despite the diagnostic difficulties with NHL, this case series and literature review determined that there are several characteristics that can be helpful in appropriately targeting the diagnostic course. Both in the presented cases and the data in the literature, the most common symptom was nonspecific abdominal pain, rather chronic and recurrent in nature, for a long period of time (about four to five weeks, on average). This is different from the pain traditionally described in idiopathic intussusception, which is sudden, colicky, recurrent, and worsens rapidly [1–3]. This difference might be important, as patients with recurrent, long-lasting abdominal pain are usually referred to pediatric wards when, in reality, they require urgent surgical evaluation and management. Patients whose intussusception was caused by Burkitt's lymphoma rarely develop symptoms of complete obstruction (as can be observed in spontaneous intussusception) but rather progress as partial obstruction. It is also worth mentioning that although the majority of patients present with ileocecal intussusception, there is a higher incidence of ileoileal intussusception in this group. Such cases should attract special attention from the consulting pediatrician and raise the suspicion of a pathological lead point earlier. Another characteristic feature of the patients described in this study was their average age of eight years, which is similar to the literature review data but significantly higher than the average age of patients suffering from idiopathic intussusception. As Burkitt's lymphoma causing intussusception is typically diagnosed at an earlier stage than Burkitt's lymphoma in general [11, 12], there are no characteristic abnormalities in the laboratory findings. This can be another factor that makes the diagnosis less obvious.

It is notable that, unlike the endemic type, the sporadic type of Burkitt's lymphoma (which we focused on in this study) is not associated with Epstein-Barr virus (EBV) infection. Serological and molecular virological tests performed to diagnose ongoing or past EBV infection do not seem to be justified in this clinical situation. Moreover, EBV diagnostic tests should not delay or influence therapeutic decisions, as intussusception is an acute condition that requires urgent surgical intervention.

In the cases presented in this study, in which a certain clinical picture of patients with intussusception caused by Burkitt's lymphoma can be drawn, it may be beneficial to perform additional imaging examinations sooner or to undertake earlier interventions in

the form of exploratory laparoscopy. Furthermore, it is essential to emphasize that the surgical team operating on a patient with the aforementioned clinical characteristics should be particularly alert to the possible presence of a neoplasm. Such suspicion should motivate the surgical team to carefully inspect the patient's abdominal cavity and, if necessary, adjust the scope of the operation accordingly. Laparoscopy may be a particularly good solution, as there are progressively more reports of good results after this type of surgery, especially with early-stage intra-abdominal lymphomas [13].

Early recognition of the disease is especially important, as the strongest predictor of event-free survival is the stage of disease at diagnosis [6, 14–17]. Complete resection of the tumor improves the treatment outcome [7, 16]. Diagnosis at an early stage also allows for fewer courses of chemotherapy, resulting in less toxicity and fewer side effects, which can sometimes be fatal or lead to secondary cancers [18, 19].

Limitations

The main limitation of this analysis, which is addressed above, is the small size of the research sample, which results from the epidemiology of the disease itself.

Conclusions

Burkitt's lymphoma is a rare cause of intussusception, but its incidence is higher in specific groups of patients. We were able to extract data about such a group of patients from our center and observe certain characteristic symptoms that differ from those commonly seen in spontaneous intussusception: several weeks of recurrent abdominal pain, nausea, vomiting, and blood in the stool. These observations are consistent with the spectrum and frequency of symptoms reported in the literature. The presentation of such a constellation of clinical features should prompt immediate suspicion of neoplastic disease as the cause of the patient's complaints, which occurred in the majority of our patients. This may, and in our cases did, subsequently lead to early surgical intervention, which usually results in earlier diagnosis and the need for fewer courses of chemotherapy.

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EFFECTS OF A DYNAMIC STRETCHING WARM-UP ON FUNCTIONAL MOVEMENT PATTERNS IN FEMALE HIP-HOP DANCERS

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: A large percentage of dancers suffer an injury to their musculoskeletal system at least once in their careers, as well as from pain caused by overloading or overtraining this system. A high frequency of injuries has been observed in hip-hop dancers. Before each workout, there should be a solid warm-up and stretching period. The lack of these two important elements increases the risk of injury.

Aim of the study: This study aimed to examine the effects of dynamic stretching warm-ups on fundamental movement patterns in female hip-hop dancers.

Material and methods: This study included 14 hip-hop female dancers, aged 15–17. Dancers participated in 6 weeks of dynamic stretching warm-ups. Anthropometric and demographic variables were measured. The effectiveness of dynamic stretching warm-ups in improving fundamental movement patterns was assessed using the Functional Movement Screen (FMS) test including qualitative assessments using Deep Squat (DS) Hurdle Step (HS), In-Line Lunge (ILL), Shoulder Mobility (SM), Active Straight-Leg Raise (ASLR), Trunk Stability Push-Ups (TSPU) and Rotational Stability (RS).

Results: Before the intervention, the mean composite FMS™ score was 15.00±1.84 points and after the intervention was 16.64±1.39 ($p<0.05$). There were also statistically significant differences before and after the intervention in the DS (1.86±0.53 vs. 2.36±0.49, $p<0.05$) and ASLR (2.21±0.69 vs. 2.57±0.65, $p<0.05$). The number of dancers who scored 14 points or less on the FMS test before and after dynamic stretching warm-ups decreased from 50% to 0%. HS ($r=0.63$, $p=0.01$) and TPSU ($r=0.79$, $p=0.01$) were positively correlated with composite FMS scores before the intervention. After the intervention, positive correlations were observed between ASLR and composite FMS scores ($r=0.68$; $p=0.01$).

Conclusions: Dynamic stretching warm-ups significantly improve functional movement patterns, including DS, ASLR, and composite FMS scores. It is important to use movement competency screenings in injury prevention programs.

KEYWORDS: FMS test, warm-up, dynamic stretching, hip-hop female dancers

Background

A professional dancer's training is based on repetitive movement patterns that expose them to various overload injuries. As part of their training, they also prepare for various competitions, which increases the intensity and number of training sessions [1–6]. Studies have shown that 20–84% of dancers have suf-

fered a musculoskeletal injury at least once in their careers, and an even higher percentage (95%) have experienced pain caused by overtraining [2].

Each training session should be preceded by a dedicated warm-up and stretching routine. The lack of these two important elements, which increase body temperature, muscle flexibility, and range of movements, may contribute to an increased risk of injury [7–11]. Increasingly, as supported by research, dynamic stretching is preferable to static because they closely imitate the patterns of exercise movements. The authors emphasize that dynamic stretching may increase nerve conduction velocities and muscle compliance while accelerating energy production [8–9, 11].

There is little research on the characteristics and prevention of injuries in hip-hop dancers and on the effects of dynamic stretching on functional movement patterns in dancers. The authors found three original articles describing the impact of various types of stretching on the range of motion, balance, and jumping abilities of dancers. According to Morrin et al. a combined warm-up protocol consisting of static and dynamic stretching is an effective warm-up for dancers [12]. The results of the study by Lobel et al. provided evidence that the effects of supine stretching transfer to standing hip flexion [13]. Research by Lima et al. on ballet dancers showed that a long duration of stretching negatively impacts the hamstring:quadriceps (H:Q) ratio in the short term, which may lead to a greater hamstring to quadriceps imbalance [14]. However, the studied groups were small – 10, 18, and 12 female dancers. Only two studies examined a control group. Therefore, the scientific evidence for these works is limited (Table 1).

Table 1. Characteristics of original interventions and their impact on various forms of stretching in dancers

Author	Publication Year	Group size	What was assessed	Assessment tool	Control group	Intervention	PEDro scale
Morrin et al. [12]	2013	F=10	Influence of static, dynamic, and combined stretching on balance and range of motion	Hamstring ROM performance measurement	No	Model of static, dynamic, or combined stretching after warming up	3/10*
Lobel et al. [13]	2016	F=18	Impact of active stretch and passive stretch on Standing Hip Range of Motion	Hip ROM measurements before and after stretching sessions	Yes	12 sessions of randomly assigned stretching techniques over 3 weeks	4/10**
Lima et al. [14]	2018	F=12, F=15 resistance trained	The effects of static stretching and ballistic stretching on concentric H:Q ratio, squat jump and countermovement jump height, and SJ:CMJ ratio	5 exercises to stretch the muscles of the lower limbs, isokinetic Strength Test, H:Q Concentric Peak Torque Ratio, Vertical Jumps	Yes	4 sessions of static stretching and ballistic stretching	2/10**

F=female, M=male.
* PEDro scale, **subjective evaluation of the authors based on PEDro.

Table 2. Characteristics of original observational works on injuries in hip-hop dancers

Author	Publication Year	Group size	What was assessed	Control group	Study design
Tsiouti et al. [15]	2021	n=320 F=48 M=272	Types of training, frequency, and causes of injuries	No	Cross-sectional cohort study
Ursej et al. [16]	2020	n=129 F=114 M=15	Types and risk factors of injuries, the frequency of injuries	No	Prospective study
Joka et al. [17]	2015	n=62 F=16 M=46	Influence of training habits and gender on the incidence of injuries	No	Cross-sectional study
Jubb et al. [18]	2019	n=73 F=45 M=28	Dancers Injury Patterns	No	Cross-sectional study
Tjukov et al. [19]	2020	n=146 F=67 M=79	Training time, types and causes of injuries, treatment, and recovery time	No	Retrospective cohort study
Bronner et al. [20]	2015	n=6 F=6	Kinematics of hip, knee, and ankle joints during movements in hip-hop dance	No	Cross-sectional study

F=female, M=male.

Six original articles describing observational studies were also found. The authors tried to find risk factors and causes of injuries and assessed the different types of injuries in hip-hop dancers. Research by Tsiouti et al. showed that 71% of hip-hop dancers have suffered an injury in the last 12 months [15]. Ursej et al. also showed a high rate of injuries in hip-hop dancers [16]. The most common locations of injuries in hip-hop dancers were the knee, wrist [17], lumbar spine, feet and ankles [16, 18, 19], the groin [19], and shoulder [15]. According to Tjukov et al. the risk of injury among dancers of all styles is considered low compared to footballers, swimmers, and long-distance runners. The amount of time spent in training was related to the injury rate [17]. According to Bronner et al. hip-hop dancers work at the weight-bearing joints' end range of motion where muscles are at a functional disadvantage [20]. These results may explain why lower extremity injury rates are high in this population (Table 2).

The above-mentioned research studies vary and have little scientific evidence. There are no studies evaluating the influence of an appropriate warm-up on the functional patterns of movement in dancers. Therefore, it is advisable to undertake further research on the risk factors of injuries in dancers and the methods of their prevention.

Aim of the study

This study aimed to examine the effects of dynamic stretching routines performed as warm-ups on fundamental movement patterns in female hip-hop dancers.

Material and methods

Study design and setting

The interventions were conducted from May to June 2021, among hip-hop dancers from the Step By Step Dance Studio in Częstochowa, Poland. Classes were conducted once a week and lasted 90 minutes. The dynamic stretching warm-up intervention was carried out for 6 weeks at the beginning of each dance class for 20 minutes before the main training.

Participants

Fourteen dancers were examined. Inclusion criteria: 1) participation in dance training with at least one year of dance experience, 2) age 15–17, 3) female gender, 4) no current injuries, and 5) written consent from the parent/legal guardian to participate in this study. Exclusion criteria: 1) lack of participation in dance training, 2) age under 15 and over 17, 3) male gender, 4) injury preventing participation in dance training, 5) poor health or malaise 6) being in quarantine due to the Covid-19 pandemic, 7) dancers who had difficulty practicing or intervening due to injury, and 8) lack of consent of the parent/legal guardian to participate in the research.

Ethical considerations

Prior to the study, all participants were informed about the purpose and protocol of the study and provided informed voluntary consent. In the case of underage dancers, consent to participate in the study was signed by a parent or legal guardian. The study protocol was developed in accordance with the Helsinki Declaration. The research was approved by the Ethics and Scientific Research Committee at the University of Opole (No. 17/2021).

Methods

Anthropometric measurements

The researchers made basic anthropometric measurements. Body height was measured with a stadiometer with an accuracy of 0.1 cm. Body weight was measured on an electronic scale with an accuracy of 0.1 kg. Next, body mass index (BMI) was calculated, and cut-offs were used to define the body habitus of the adolescents [21].

Questionnaire

The anthropometric research was supplemented by a questionnaire. The questionnaire included questions about: age, place of residence (city/village), experience in dancing, and injuries (yes: what kind of injuries and when/no)

Assessments

The effectiveness of dynamic stretching warm-ups was assessed using the Functional Movement Screen (FMS) test. The test was performed twice. Prior to the intervention, participants were examined using the FMS test. Next, they performed dynamic stretching warm-ups for 6 weeks. After this time, they were re-examined using the FMS test. The FMS test and dynamic stretching warm-up program was explained and supervised by a qualified physiotherapist trainer and physiotherapist.

FMS test

A functional assessment using the FMS test was performed. The FMS test is a pre-participation screening tool designed to identify compensatory movements and patterns that are indicative of an increased risk of injury and inefficient movements that can reduce one's performance [22,23].

The test exhibits reliability of measurements between subjects (ICC Inter-rater=0.87–0.89) and examiners taking them (ICC Intra-rater=0.81–0.91). Excellent inter-rater and intra-rater reliability were demonstrated by Bonazza, Smuin, Onks, Silvis, and Dhawan [24].

The FMS is composed of seven movements that are scored: Deep Squat [DS], Hurdle Step [HS], In-Line Lunge [ILL], Active Straight-Leg Raise [ASLR], Rotational Stability [RS], Shoulder Mobility [SM], and Trunk Stability Push-ups [TSPU] were used to identify asymmetries and/or deficiencies in movement competency [22, 23].

FMS testing is used to detect existing functional limitations and expose asymmetries between the left and right sides in relation to a given task. In asymmetrical tests (HS, ILL, SM, ASLR, and RS), the left and right sides can be assessed independently. Positions in which the subject is forced into during exercises allow for a smooth and accurate indication of weak links and irregularities during the task [22, 23].

Each movement was scored using a 0–3 scale. Each of the movements was scored using standard criteria. The scores refer to:

3 – unquestioned ability to perform the functional movement pattern,

2 – ability to perform a functional pattern, but with some degree of compensation,

1 – inability to perform or complete a functional movement pattern,

0 – indicates the participant had pain during the performance of the exercise [22, 23].

Each movement was scored using this 0–3 scale and summed to determine a composite score ranging from 0–21 points. Each movement should be performed three times for each the right and left. The result with the best technical performance was recorded. In the case of bilateral tests, the lower value should be recorded. A result below 14 points indicates a 50% risk of sustaining an injury.

In order to minimize external factors, all motor tasks were performed in a well-lit and soundproofed room. Original, certified FMS equipment was used. Measurements were conducted at the same time of day to minimize the effect of diurnal variations on the selected variables.

The FMS has excellent inter-rater and intra-rater reliability. Participants with composite scores of ≤14 had a significantly higher likelihood of an injury compared to those with higher scores, demonstrating the injury predictive value of the test [24].

Intervention

The dancers participated in a 6-week training program, once a week, every Monday in the form of a dynamic stretching warm-up performed before each main dance training session.

The training was carefully supervised by a qualified choreographer and physiotherapist. The dancers did not perform any additional physical activity during the study.

Exercise

Each exercise session lasted 20 minutes: 5 minutes of running and walking with the next 15 minutes consisting of dynamic exercises. The dynamic stretching warm-ups were comprised of 15 specific exercises, each performed for 1 minute (Table 3).

Table 3. Dynamic Stretching warm-up program (exercises)

No	Name	Starting position	Movement	Number of repetitions
1	Arm swings	Stand with feet shoulder-width apart and arms out to the side at shoulder height.	Arms cross	30 reps
2	Spinal rotation	Stand with feet shoulder-width apart and arms out to the side at shoulder height.	Keep the torso still and slowly start to rotate the body back and forth from right to left.	15 reps on each side
3	Standing bicycle crunches	Stand with feet shoulder-width apart and arms behind head, pointing elbows outward.	Raise the right knee across the body, simultaneously twist the torso to the right and draw left elbow towards the lifted knee. Exhale during the movement. Then return to the starting position and repeat the same movement on the other side.	15 reps on each side
4	Forward leg swings	Stand with feet shoulder-width apart	Swing forward and backward. Bring that leg down and repeat with the other leg.	15 reps on each side

Table 3 contd.

No	Name	Starting position	Movement	Number of repetitions
5	Lateral leg swings	Stand with feet shoulder-width apart	Swing lateral. Bring that leg down and repeat with the other leg.	15 reps on each side
6	Lunge with a twist	Stand with feet shoulder-width apart	Reverse lunge with a torso twist	15 reps on each side
7	Fire hydrant exercises	Tabletop. Hands shoulder-width apart with wrists, elbows, and shoulders in one line. Hips over knees, with knees hip-width apart.	Bend left leg to 90 degrees. Lean trunk forward and squeeze your core. Lift leg to 45 degrees without moving the rest of the body.	15 reps on each side
8	Tabletop + leg swing	Tabletop. Hands shoulder-width apart with wrists, elbows, and shoulders in one line. Hips over knees, with knees hip-width apart.	Leg swings	15 reps on each side
9	Cat-cow	Tabletop. Hands shoulder-width apart with wrists, elbows, and shoulders in one line. Hips over knees, with knees hip-width apart.	Cat and cow position	30 reps
10	Upward-facing dog – Downward-facing dog	Upward-facing dog	Downward-facing dog	30 reps
11	Supermans	Lie face down on the ground and stretch both arms out in front of the body, keeping the legs stretched out and flat on the ground.	Raise both hands. Try to pull in the belly button, lifting it off the floor to engage the core muscles. Keep the head straight and look at the floor to avoid neck injury.	30 reps
12	Cross over oblique crunch	Lay on the mat. Place hands behind your head with elbows out. Bend knees.	Twist the torso to your left, bringing the right hand to the left toe until they touch.	30 reps
13	Supine Trunk Rotation with Feet Raised	Lay on the mat. Hands to the side. Feet raised off the floor with the legs in a 90/90 position.	While holding the abdominal brace slowly rotate your knees to one side. The outstretched arms can help balance this movement by pressing into the floor.	15 reps on each side
14	Yoga Boat Pose (Navasana)	Sitting up straight with legs bent, keeping your feet flat on the floor.	Press legs together, slowly lift them off the floor until they form a 45-degree angle to the torso. Keeping back flat. Straighten out legs.	30 reps
15	Overhead arms raise	Sitting up straight with legs straight. Arms along the torso.	Overhead arms raise	30 reps

Statistical analysis

Descriptive statistics were used. The mean, standard deviation (SD), median (Me), quartile 1st (Q1), and quartile 3rd (Q3) were calculated. The distribution of variables was assessed for normality using the Shapiro-Wilk test. Non-parametric statistics were used. The Wilcoxon test was used to calculate the differences in dependent samples. The Spearman's rank correlation was used to assess the relationship between the Composite FMS scores and individual components. All calculations were performed using Statistica version 13.3 (TIBCO Inc., USA). A level of p-value ≤0.05 was adopted in the assessment of statistical significance.

Results

Participants

Table 4 presents the characteristics of the basic anthropometric and demographic variables of the female dancers.

Table 4. Descriptive statistics for anthropometric and demographic variables

Variables	Descriptive statistics	Results
Age [lata]	M±SD Me Q1–Q3	15.79±0.97 16 15–17

Table 4 contd.

Variables	Descriptive statistics	Results
Body height [cm]	M±SD Me Q1–Q3	162.50±7.99 165 158–170
Body mass [kg]	M±SD Me Q1–Q3	51.25±6.66 50.75 46–58
BMI [kg/m2]	M±SD Me Q1–Q3	19.46±2.59 19.40 17.43–20.75
BMI categories	Normal Underweight	9 (64.29%) 5 (35.71%)
Place of residence	urban area rural area	11 (78.57%) 3 (21.43%)
Dance experience [years]	M±SD Me Q1–Q3	3.29±2.36 3 1.40–4
Previous injuries	Yes No	1 (7.14%) 13 (92.86%)

Note: M – mean, SD – standard deviation, Me – median, Q1 – quartile 1st, Q3 – quartile 3rd.

Main results

Table 5 presents the results of differences in the FMS test before and after the dynamic stretching warm-up intervention. Statistically significant differences were observed in DS (p=0.02), ASLR (p=0.04), and composite FMS (p=0.01). The number "0" in the N valid column for RS means that none of the dancers changed their results.

Other analyses

Spearman's rank correlation calculation revealed the performances on the HS (r=0.63, p=0.01) and TPSU (r=0.79, p=0.01) were correlated with the composite FMS scores before intervention (Table 6). After the intervention, ASLR (r=0.68; p=0.01) was correlated with composite FMS scores (Table 7).

Table 5. Significance of differences before and after the dynamic stretching warm-up program

Variables	Descriptive statistics	Before	After	N	Z	p
DS	M±SD Me Q1–Q3	1.86±0.53 2 2–2	2.36±0.49 2 2–3	7	2.3664	0.0179*
HS	M±SD Me Q1–Q3	2.14±0.36 2–2	2.29±0.47 2 2–3	2	1.3416	0.1797
ILL	M±SD Me Q1–Q3	1.86±0.53 2 2–2	2.07±0.27 2 2–2	3	1.6036	0.1088
SM	M±SD Me Q1–Q3	2.57±0,65 3 2–3	2.86±0.36 3 2–2	4	1.8257	0.0679
TPSU	M±SD Me Q1–Q3	1.64±0.49 2 1–2	1.86±0.36 2 2–2	3	1.6036	0.1088
RS	M±SD Me Q1–Q3	2.71±0.47 3 2–3	2.71±0.47 3 2–3	0		
ASLR	M±SD Me Q1–Q3	2.21±0.69 2 2–3	2.57±0.65 3 2–3	5	2.0226	0.0431*
FMS composite score	M±SD Me Q1–Q3	15.0±1.84 15 14–16	16.64±1.39 16 16–18	11	2.9340	0.0033*
	score ≤14	50%	0%			

Note: DS – deep squat, HS – hurdle step, ILL – in-line lunge, SM – shoulder mobility, TPSU – trunk stability push-up, RS – rotary stability, ASLR – active straight leg raise, M – mean, SD – standard deviation, Me – median, Q1 – quartile 1st, Q3 – quartile 3rd, N – absolute difference scores (actual sample size), Z – Wilcoxon test, *p<0.05.

Table 6. Spearman's rank correlation between composite FMS scores and individual components. Data were displayed as Spearman correlation (R) and significance (p-value) before the dynamic stretching warm-up intervention.

Before	DS	HS	ILL	SM	TPSU	RS	ACLR
Composite FMS	0.53	0.63*	0.53	0.48	0.79**	0.08	0.45

Note: DS – deep squat, HS – hurdle step, ILL – in-line lunge, SM – shoulder mobility, TPSU – trunk stability push-up, RS – rotary stability, ASLR – active straight leg raise, *=p ≤ 0.05, **=p ≤ 0.01.

Table 7. Spearman's rank correlation between composite FMS scores and individual components. Data were displayed as Spearman correlation (R) and significance (p-value) after the dynamic stretching warm-up intervention

After	DS	HS	ILL	SM	TPSU	RS	ASLR
Composite FMS	0.50	0.40	0.48	0.41	0.41	0.00	0.68*

Note: DS – deep squat, HS – hurdle step, ILL – in-line lunge, SM – shoulder mobility, TPSU – trunk stability push-up, RS – rotary stability, ASLR – active straight leg raise, *=p ≤ 0.05.

Discussion

Key results

An effect of a dynamic stretching warm-up on functional movement patterns in female hip-hop dancers was found.

Interpretation

The research showed that the use of a 6-week dynamic stretching warm-up program before training improved the results of DS, ASLR, and the composite FMS test. The DS test allows you to assess the functional mobility of the hip, knee, and ankle joints and by holding the bar over the head, it allows you to assess the mobility of the shoulder girdle and thoracic spine. The ASLR test assesses the functional flexibility of the hamstrings as well as the passive flexibility of the iliopsoas muscle of the contralateral limb. After a series of dynamic stretching warm-ups, improved mobility of the joints of the lower extremities, mobility of the shoulder girdle, and the thoracic spine were found. Additionally, increased flexibility of the hamstrings and iliolumbar muscles were seen. More favorable results in the DS, ASLR, and composite FMS test may be the result of many factors, but it can be assumed that the use of a dynamic stretching warm-up program increased the range of motion of joints by directly affecting the tissues surrounding the joints and muscles. Mobility is the ability to apply muscle strength and control them during movements at the extremes of one's range of motion. Thus it is one of the main elements in disciplines such as weightlifting, gymnastics, and martial arts, i.e. wherever high performance and muscle strength in the extreme range of mobility is needed.

There are no studies describing the influence of warming up and the applied form of stretching in hip-hop dancers. The results of the few studies on other dancers are mixed. Morrin et al. assessed the impact of static stretching, dynamic stretching, and a combined (static and dynamic) stretching protocol on vertical jump height, balance, and range of motion in dancers. From the comparison of the stretch protocols used in the study, it can be concluded that static stretching does not appear to be detrimental to a dancer's performance, and dynamic stretching has some benefits but not in all three key areas tested. However, combination stretching showed significantly enhanced balance and vertical jump height scores and significantly improved pre-stretch and post-stretch range of motion values [12]. Lobel et al. researched the impact of passive stretch and active stretch on standing hip range of motion in female dancers. Both of the stretching groups had statistically significant increases in standing hip flexion angles during the standing hip flexion test. The passive stretch group had greater increases than the active stretch group [13]. The study by Lima et al. aimed to compare the effects of static stretching and ballistic stretching on the concentric H:Q ratio, squat jump (SJ) height, countermovement jump (CMJ) height, and the SJ:CMJ ratio between ballet dancers and resistance-trained women. The authors showed that ballet dancers and resistance-trained women decreased their H:Q ratios similarly following ballistic and static stretching. Therefore, regardless of stretching type, there was a negative effect on muscle function in the short term. However, vertical jump height and SJ:CMJ ratios were not negatively affected by either type of stretching in the two groups [14].

There has been much more research on the effects of stretching on athletes or non-training people. Review studies have had varying results. Behm et al. compared the effects of static stretching, dynamic stretching, and proprioceptive neuromuscular facilitation (PNF) stretching on performance, range of motion, and injury prevention. Static stretching- (–3.7%), dynamic stretching- (+1.3%), and PNF-induced (–4.4%) performance changes were typically small to moderate in (relative) magnitude when testing was performed soon after stretching. An initial assumption based on the overall results may be to not recommend static or PNF stretching in pre-event warm-up activities when testing performance is required immediately after stretching. Static stretching and PNF showed no overall effect on all-cause injury or overuse injuries, but there may be a benefit in reducing acute muscle injuries in running, sprinting, or other repetitive contractions. Limited data indicates a potentially greater effect of static stretching and PNF on injury risk for longer stretch durations (>5 minutes of total stretch time for task-related multiple muscle groups). Considering the small-to-moderate changes immediately after stretching and the study limitations, stretching within a warm-up

that includes additional post-stretching dynamic activities is recommended for reducing muscle injuries and increasing joint range of motion [25]. The aim of the systematic review and meta-analysis by Afonso et al. was to compare the effects of supervised and randomized strength training compared to stretching protocols on the range of motion in participants of any health and training status. Qualitative synthesis showed that strength training and stretching interventions were not statistically different in improving range of motion. However, the studies were highly heterogeneous with regard to the nature of the interventions and moderator variables, such as gender, health, and training status. This was reported in the original manuscripts as well. A meta-analysis, including 11 articles and 452 participants, showed that strength training and stretching interventions were not statistically different in active and passive ROM changes [26]. Hammami et al. assessed the current research that examined the efficacy of warm-up and re-warm-up on physical performance in soccer players. This review demonstrated that a static stretching warm-up reduced acute subsequent performances, while warm-up activities that include dynamic stretching elicited positive effects in soccer players [27].

Also, more intervention studies on the impact of various forms of stretching concern athletes or healthy untrained people. A study by Sobota et al. involving amateur long-distance runners found that the group who used a longer dynamic warm-up period before training and static stretching after training had an average composite FMS score of 17.08 whereas those who did not perform these activities had a score of 15.50 [28]. In regards to runners, insufficient warm-up was also a cause of injury [29]. Iwata et al. examined the effects of dynamic stretching of the hamstring muscles on passive knee extension, passive torque at the onset of pain (as a measure of stretch tolerance), and passive stiffness of the muscle-tendon unit over an extended period after stretching. The results indicated that when performed prior to exercise, dynamic stretching is beneficial for the hamstring muscles in terms of increasing flexibility and reducing stiffness [30]. Konrad et al. assessed the effect of combined treatment on ROM and compared it to the effect of stretching, foam rolling, and a control condition by applying a random-effect meta-analysis. Athletes do not have to combine stretching with foam rolling since no additional effect was observed. However, to increase performance, the combination of foam rolling followed by stretching can lead to greater improvements [31].

In our research, hip-hop dancers obtained the lowest results in TSPU which assesses the stability of the torso in the sagittal plane. The average test results before dynamic stretching warm-ups were 1.64±0.49 points and 1.86±0.36 points after. On the other hand, the highest-scoring test was the RS which assesses the rotational trunk stability – 2.71±0.47 points both before and after the stretching program. The opposite results were obtained by American researchers who researched ballet dancers. The mean TSPU score was 2.19 but the RS was 1.88 points, and the RS score was the lowest score among other FMS trials [32].

The composite FMS test significantly improved after applying dynamic stretching warm-ups from 15.0±1.84 to 16.64±1.39 points. Despite the improvement, the mean composite FMS test results remained in the range of 15 to 18 points, which means the presence of compensation and asymmetry in female dancers and risk of injury of 25–35%. Results in the range of 18–21 points mean correct functional movement patterns and a low risk of injury [33]. Few researchers have used the FMS test in dancers. In the studies by Misegades et al. ballet dancers obtained an average composite FMS score of 15.32 points, which, similarly to our research, means the presence of compensation and asymmetry and injury risk of 25–35% [32]. Kautzman et al. assessed 111 dancers with the FMS test. The total FMS scores ranged from 11 to 20 points, with a mean of 16.42±1.72. Forty-four percent of dancers presented with one or more asymmetries and 43% demonstrated one or more dysfunctional movement patterns. The ASLR was the most proficiently performed movement pattern, while the DS, HS, and RS were the least proficient. FMS outcome scores indicated that dysfunctional movement patterns and asymmetries exist in collegiate dancers [34].

The results of our research show that in dancers there are compensations and asymmetries and the risk of injury is medium to high. Implementation of mobility exercises, longer warm-ups, and dynamic stretching before training may improve functional movement patterns and may reduce the risk of injury.

Strengths

The strength of our study is the use of the original FMS test. The reliability of the FMS test was assessed by Smith et al. [35]. The test exhibits reliability between subjects (ICC Inter-rater=0.87–0.89) and good consistency between the same examiner's assessments (ICC Intra-rater=0.81–0.91). Excellent inter-rater and intra-rater reliability were also demonstrated by Bonazza et al. [24]. A study by Minick et al. showed that the FMS test can be confidently applied by trained individuals [36].

Limitations

This study also has limitations. The first limitation is the small study group and the lack of a control

group. It would be worthwhile to conduct research on a larger number of people in the future, including a control group. The studies also did not take into account the possible influence of the menstrual cycle on motor performance. Future research will need to be carried out taking into account the menstrual cycle, as hormonal changes have a huge impact on motor performance. Another limitation is that some researchers question the prognostic accuracy of the FMS test [37, 38]. These studies suggest that the FMS test may be useful in identifying defects in certain movements, but should not be used for the general prediction of injuries.

Conclusions

Statistically significant differences were found in DS, ASLR, and composite FMS scores. The use of dynamic stretching warm-ups has a positive effect on functional movement patterns. The dancers obtained the fewest points in TPSU, which suggests that trunk stability exercises should be included in the training. It is important to include examinations of movement competency screenings in injury prevention programs.

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THREE PERSPECTIVES: THE APPROACH TO NEOADJUVANT TREATMENT OF RECTAL CANCER ACCORDING TO MEDICAL ONCOLOGISTS, RADIATION ONCOLOGISTS, AND SURGEONS

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ABSTRACT

Background: Two treatment options considered for radiotherapy are short-course radiotherapy and immediate surgery, or chemoradiation with 5-Fluorouracil based chemotherapy and delayed surgery.

Aim of the study: Evaluate the real-life treatment approaches of medical, radiation, and surgical oncologists, to neoadjuvant treatment of rectal cancers.

Material and methods: An online survey was established via Google Forms. The survey was taken voluntarily by medical oncologists, radiation oncologists, surgical oncologists, and general surgeons.

Results: Of those who participated, 183 were medical oncologists, 36 were radiotherapists, and 36 were surgeons. Most of the study population preferred long-course radiation therapy and chemotherapy (85%). Meanwhile, two-thirds of the participants preferred chemotherapy prior to operating. The most frequent chemotherapy cycles for the pre-operative setting were 'three' and 'four-or-more' (27.8% and 25.1%, respectively). Medical oncologists had a significantly higher tendency to offer chemotherapy between radiation therapy and surgery compared to the other groups. Optimal time of surgery was different between groups, but there was no difference among groups between surgery and the 'watch & wait' strategy. Neoadjuvant chemotherapy regimens were significantly different between groups.

Conclusions: We found that the new pre-operative chemotherapy regimen with short-course radiotherapy was slowly adopted into current practice. Also, medical oncologists tended to prefer pre-operative chemotherapy in comparison to the other groups.

KEYWORDS: chemotherapy, neoadjuvant treatment, radiotherapy, rectal cancer, treatment modalities

Background

Chemoradiation (CRT) is the gold standard of care in newly diagnosed rectal cancers.[1] The main objective of the treatment is to improve surgical outcomes, prevent local recurrence, and to prolong disease-free survival (DFS) and overall survival (OS). Two treatment options are considered for such radiation therapy, which includes short-course radiotherapy (RT) and immediate surgery, or CRT with 5-Fluorouracil (5-FU) based chemotherapy (CT) and delayed surgery.[1,2] In controversial areas in particular, the initial treatment plan is mainly dependent on the decision of the treating physician.[3] Both treatment options have similar results in terms of survival and resection margin 0 surgery

frequency, as well as distant and local recurrences. However, pathological complete response (pCR) rates are higher in long course RT in combination with CT [4]. Furthermore, local and distant recurrence rates favored complete remission (CR) after CRT compared with non-responders after surgery. [5] Prior research has demonstrated that the addition of multidrug (only oxaliplatin-containing) regimens was not related to increased pCR, but resulted in higher rates of toxicity. A modest benefit was observed with the addition of oxaliplatin to 5-FU and radiation [6].

Rectal cancers with mid or low location (infraperitoneal) that are at stage T3-4, or have nodal metastasis, are recommended by current guidelines to receive CRT therapy. Also, circumferential resection margin (CRM) involvement is an indication for neoadjuvant treatment. As such, total neoadjuvant treatment may be offered in addition to current guidelines, including the folinic acid, fluorouracil, oxaliplatin and irinotecan (FOLFOXIRI) regimen. [7] Although CRT was associated with decreased local recurrence, no improvement was observed in OS.[1,8] CRT mainly resulted in downsizing in the majority of patients (70%), though this was even less so in those with a pCR (20%). However, pCR was related to a good prognosis and an excellent OS of over 90%.[9]

Although small tumors have a better response to CRT, there are multiple controversial factors that determine the response to CRT. Indeed, the optimal interval after CRT to surgery is still unknown. This was investigated during the Lyon trial, which compared two weeks delay with six weeks delay after CRT, the latter of which resulted in increased pCR and near pCR rates.[10] The main reason for increasing the time to surgery after CRT is the delayed lysis of tumor cells after immediate DNA damage with CRT, with cells reported to be morphologically intact shortly after RT.[11,12] Multiple other studies have evaluated the optimal time for surgery after CRT, but no correlation was found between the studies.[13–15] In a Canadian study evaluating surgical attitudes to rectal cancer, the waiting period after CRT was mostly determined to be six weeks. Also, low numbers of the 'Watch & Wait' strategy were observed. The study focused mainly on surgical techniques used and not selection of the type of treatment. Different surgical types investigated in this study included microscopic anal resection and total mesorectal surgery.[16] Additionally, a survey based study was carried out in the Netherlands to acquire information about the preferences and awareness of surgeons, especially regarding lateral lymph nodes status.[17]

In radiological studies, the tumor position, maximum distance from the anal verge, maximum tumor length, thickness, area, and volume, have been evaluated. These factors, except for tumor thickness, were reported to be a marker for pCR.[18] Different treatment preferences, especially in controversial areas in colon cancer, have also been previously studied.[19,20]

Aim of the study

To evaluate the real-life approaches of medical oncologists, radiation oncologists, surgical oncologists, and general surgeons, to neoadjuvant treatment of rectal cancers.

Material and methods

Study design and setting

An online survey form was established using Google Forms, and was answered voluntarily by medical oncologists, radiation oncologists, surgical oncologists, and general surgeons. Access to the survey commenced on 1st November 2021 and ended on 29th November 2021.

Participants

A link to the online survey was sent via e-mail and mobile applications to all oncologists, radiotherapists, and surgeons, who were registered to their professional associations in Turkey. Recipients of the survey included 867 medical oncologists, 248 radiotherapists, and 217 surgeons. A total of 255 recipients responded, 183 of which were medical oncologists, 36 were radiotherapists, and 36 were surgeons.

Survey

Consent was acquired from participants at the beginning of the survey and they were informed that their preferences in rectal cancer treatment would be evaluated. Participants were asked to answer questions on optimal conditions, such as treatment options and imagining methods. The survey contained 14 questions that were designed to understand the participants' experience, working conditions, and rectal cancer treatment decisions. Two questions were mandatory for medical oncologists, but were not required to be answered by the other participants. Answering all other questions was mandatory. Information about experience in oncology practice, academic status, and the type of

hospital in which they operate, was obtained from all participants.

Statistical analysis

Survey results were analyzed using descriptive statistics, and Chi-square tests were used to calculate p values, using SPSS® version 21.0 (IBM Corporation, NY, USA). Also, the difference between percentages was analyzed by Z-test using e-PICOS software (MedicRes, NY, USA). The level of significance was determined as $p<0.05$. No sample size evaluation was performed due to the survey nature of the study.

Ethics

The study was carried out according to the principles of the Declaration of Helsinki and all applicable regulations. Participants declared that they filled the form in voluntarily. There were no promotions or gifts offered to increase participation.

Results

The number of recipients for each group totaled 867 medical oncologists, 248 radiotherapists, and 217 surgeons. A total of 255 recipients responded to the survey, of which 183 were medical oncologists, 36 were radiotherapists, and 36 were surgeons. Nineteen of the surgeons were surgical oncologists and 17 were general surgeons. Participants were mostly aged between 30 to 40 years (61.2%) and almost half of them had less than five-years of experience in oncology practice. Most of the study population were fellows or specialists (75%), and there was a significant difference between oncologists, radiotherapists, and surgeons, in terms of experience. Indeed, medical oncologists had less experience in their field when compared to other specialists ($p<0.001$). Forty-six percent of respondents were working in university hospitals, and almost 50% had examined five or fewer newly diagnosed rectal cancers. Most of the study respondents preferred long-course radiation

Table 1. Features of the study population

Profession	Medical oncologists	Radiation oncologists	Surgeon	
N (%)	184 (72.2)	36 (14.1)	35 (13.7)	
Age (years)	30–40	41–50	51–60	61–70
N (%)	156 (61.2)	77 (30.2)	18 (7.1)	4 (1.6)
Experience (years)	5 or less	6–10	11–20	21–30
N (%)	122 (47.8)	49 (19.2)	67 (26.3)	17 (6.7)
Position	Fellow	Specialist	Assoc. Prof	Professor
N (%)	97 (38)	95 (37.3)	31 (12.2)	32 (12.5)
Facility	State H.	Res. & Edu H.	University H.	Private H.
N (%)	21 (8.2)	81 (31.8)	118 (46.3)	32 (12.7)
(Monthly) Rectal Cancer	5 or less	6–10	11 or more	
N (%)	123 (48.2)	91 (35.7)	41 (16.1)	

H: Hospital; Res. & Edu. H.: Research and Educational Hospital; CT: Chemotherapy; Neo-adj: Neo-adjuvant; 5-FU: 5-Fluorouracil; XELOX: Oxaliplatin plus Capecitabine; Folfox: Oxaliplatin, Leucovorin, 5-Fluorouracil; W.: Week; CR: Complete Remission.

Table 2. Treatment preferences of the study population

Questions	Preferences				
Neo-adj treatment	Short-course	Long-course +CT			
N (%)	37 (14.5)	218 (85.5)			
Neo-adj CT	Yes	No			
N (%)	157 (61.6)	98 (38.4)			
Neo-adj Cycles	0	1	2	3	4 or more
N (%)	40 (15.7)	50 (19.6)	30 (11.8)	71 (27.8)	64 (25.1)
Type of CT	None	Capecitabine/5-FU	XELOX	Folfox	
N (%)	62 (24.3)	35 (13.7)	102 (40)	56 (22)	
Optimal time for surg.	6 w. or before	7–8 w.	9–10 w.	11–12 w.	13 w or later
N (%)	43 (16.9)	122 (47.8)	38 (14.9)	48 (18.8)	4 (1.6)
CR strategy	Surgery	Watch & wait			
N (%)	210 (82.4)	45 (17.6)			

H: Hospital; Res. & Edu. H.: Research and Educational Hospital; CT: Chemotherapy; Neo-adj: Neo-adjuvant; 5-FU: 5-Fluorouracil; XELOX: Oxaliplatin plus Capecitabine; Folfox: Oxaliplatin, Leucovorin, 5-Fluorouracil; W.: Week; CR: Complete Remission.

therapy and CT (85%). Two-thirds of the participants preferred CT prior to surgery, with the most frequent CT cycles in the pre-operative setting being 'three' and 'four-or-more' (27.8% and 25.1%, respectively). Forty percent of the participants preferred the oxaliplatin and capecitabine (XELOX) protocol, whilst 54 of the medical oncologists favored adjuvant CT, even if the patient had CR after neoadjuvant treatment. Nearly half of the study participants considered the 7th and 8th weeks to be the optimal time for surgery. Meanwhile, most of the study population favored surgery even if the patient had CR after neoadjuvant treatment (82%). Features of the study population are described in Table 1 and their main treatment preferences are described in Table 2.

There was a difference in age between groups in terms of specialization, with medical oncologists being of a younger age in comparison to other branches ($p<0.001$). Medical oncologists also had significantly less experience when compared with radiation oncologists and surgeons ($p<0.001$). Furthermore, there were no fellows in the radiation oncology and surgeon groups, which was nearly 50% of the medical oncology subset ($p<0.001$). There was no difference in the use of short or long-course radiation plus CT between groups ($p=0.09$). However, medical oncologists had a significantly higher tendency to offer CT between radiation therapy and surgery compared with the other groups ($p<0.001$).

The optimal time of surgery was different between groups ($p=0.006$) (see Table 3). However, the decision on optimal time of surgery among surgeons was not different between surgical oncologists and general surgeons, with both favoring 7-8 weeks and 11-12 weeks to the same degree ($p=0.98$). Forty-two percent of the surgeons declared that they use neoadjuvant CT between CRT or short-term RT and surgery. The utility of CT cycles was equal in terms of '3' and '4 or more' among surgeons, at 17.1%. Meanwhile, 51% of the surgeons did not offer CT until the time of surgery. There was a significant difference between groups in post hoc analysis (see Table 4). There was no difference among groups between surgery and the 'watch & wait' strategy ($p=0.11$). A significant difference was observed between groups in terms of the neoadjuvant CT regimens offered ($p<0.001$) (Table 5).

Table 3. Optimal operation time according to groups

Time of surgery	Medical oncologists	Radiation oncologists	Surgeon
6 w. of before	36 (a)	2 (a)	5 (a)
7–8 weeks	93 (a)	16 (a)	13 (a)
9–10 weeks	21 (a)	12 (b)	5 (a, b)
11–12 weeks	30 (a)	6 (a, b)	12 (b)
13 w. or after	4 (a)	0 (a)	0 (a)

* Different letter shows statistical significance between groups in post-hoc analysis (a,b).

Table 4. Chemotherapy cycles offered before surgery according to groups

Offered cycles	Medical oncologists	Radiation oncologists	Surgeons
0	0 (a)	22 (b)	18 (b)
1	47 (a)	0 (b)	3 (a, b)
2	20 (a)	8 (a)	2 (a)
3	63 (a)	2 (b)	6 (a, b)
4 or more	54 (a)	4 (a)	6 (a)
Total	184	36	35

* Different letter shows statistical significance between groups in post-hoc analysis (a,b).

Table 5. Chemotherapy regimens offered according to groups

Offered regimen	Medical oncologists	Radiation oncologists	Surgeons
Capecitabine/ 5-FU	17 (a)	5 (a, b)	13 (b)
XELOX	93 (a)	8 (b)	1 (c)
Folfox	45 (a)	3 (a)	8 (a)
None	29 (a)	20 (b)	13 (b)

* Different letter shows statistical significance between groups in post-hoc analysis (a,b), 5-FU: 5-Fluorouracil; XELOX: Oxaliplatin plus Capecitabine; Folfox: Oxaliplatin, Leucovorin, 5-Fluorouracil.

Discussion

Similarities and differences in neoadjuvant treatment of rectal cancer by radiotherapists, medical oncologists, and surgeons, were evaluated. The ultimate goal of neoadjuvant treatment is CR, which can be achieved by different treatment models for different risk stratification. In patients who had pCR after neoadjuvant CRT, long-term outcome was reported to be excellent, with less local and distant recurrence. Indeed, pCR rates were demonstrated to be between 15-27% after neoadjuvant CRT and delayed surgery. [21] Although pCR is considered to be a good prognostic factor, 5-year OS is still the main determinant in this patient group.[22] Furthermore, Valentini et al showed 2 years DFS to be a better prognostic factor than pCR.[23] As such, the clinic utility of pCR is still controversial and needs to be further investigated. In contrast to other studies, our study population was formed of high numbers of CR patients. This has allowed for a valuable source of information in this patient group to be established, which may be valuable for future meta-analysis.

Response to CRT may be related to delays in carrying out surgery, [24] with the first strong study showing that six weeks of delay until surgery increased pCR in patients when compared to two weeks.[25] In another large study, 10-11 weeks of delay until surgery after neoadjuvant CRT had the highest pCR rates, though no increased response

rates were observed with waiting beyond this time interval.[26] Furthermore, retrospective data indicated that prolonging the interval between CRT and surgery increased CR rates, with Moore et al and Tulchinsky et al. demonstrating that waiting more than seven weeks increased CR rates significantly. [24,27] Another study confirmed this, and showed that an eight week waiting period doubled CR rates. [28] This data was strengthened further following a meta-analysis in 2005, which showed better outcomes and CR rates without significant morbidity. [29] However, waiting longer than 11 weeks did not result in a favorable outcome, as comparing a 7 week to an 11 week interval between CRT and surgery failed to show increased CR rates.[30] Similar to our results, there was no difference between a 4 and 8 week waiting period between CRT and surgery in a Turkish population study.[31] In our study, most of the participants considered the 7-8th and 11-12th weeks to be the optimal period for surgery. Meanwhile, a very small subset of the study population declared that they prefer to perform surgery after more than 13 weeks. Although a longer waiting period to surgery has been shown to increase CR rates, the optimal duration of the interval has yet to be firmly established.

Effects of genetic and racial differences on tumor response is not known, though data from Saglam et al. suggests that race had an impact on tumor response in the Turkish population.[31] Our findings were substantially similar to the findings from research conducted among Canadian surgeons in terms of optimal surgery time.[16] A higher rate of surgery before six weeks was found in this trial, which might be related to short-course radiation treatment without CT, and there was no difference between surgeons, oncologists, and radiotherapists. Another scenario-based questionnaire study did find a difference between optimal time of surgery decisions among surgeons, gastrointestinal oncologists, and radiotherapists. However, this study was focused on only the 6th and 8th weeks after CRT. [32]

The second controversial area is the addition of neoadjuvant CT to the treatment plan, whilst the optimal protocol and number of cycles remain under question. Garcia-Aguelar showed that adding two cycles of CT, including 5-FU, oxaliplatin, and leucovorin, increased pCR rates to 38%. In our study, more than 20% of patients received neoadjuvant CT, though there was no effect on prognosis in terms of OS. Also, the CT protocols and cycles were not eligible.[33] Preference for neoadjuvant CT was significantly higher amongst medical oncologists than in surgeons and radiotherapists. In a study by Lefevre et al., long-term CRT was preferred in the absence of contraindications, although there were differences between the groups analyzed. Indeed, the addition of neoadjuvant CT was not a frequent option for the three groups consisting of surgeons, gastrointestinal oncologists, and radiotherapists.[32] Compatible with our results, Hazen et al. reported long-term CRT with or without radiation boost was the most preferred option amongst colorectal surgeons. However, there were differences between the colorectal surgeons in their study when compared to the surgeons in the current study. [17]

Selection of treatment strategy is largely dependent on primary risk factors and post-surgical margins. In the very-low risk group, which is evaluated with endoscopic ultrasonography, the main treatment option is considered to be primary surgery. Indeed, treatment of low-risk patients with short-course RT and conventional long-course RT with concurrent CT yielded similar results.[34] However, recent published data demonstrated that conventional treatment had similar results to short-course RT followed by pre-operative oxaliplatin and CT, if the post-operative margin was at risk.[35] Differences between medical oncologists and other groups may depend on concerns of recurrence in particular groups, with a study investigating treatment preferences of radiation oncologists showing that most still prefer long-course RT. Meanwhile, Short-course RT was mainly preferred for patients who were not candidates for CT or where there were social barriers to long-course treatment. [36]

The 'Watch & Wait' strategy was less frequently selected in our study group (17%). In a study published by Crawford et al., 4.6 percent of participants selected the 'Watch & Wait' strategy, with 54.6% stating that they chose their strategy on a case by case basis and 40.9% favoring surgery.[16] Another study, investigating radiation oncologists, demonstrated that the 'Watch & Wait' strategy was preferred by 46%, which correlated with the OnCoRe trial. [37]

Limitations

The study was a survey that attempted to evaluate pitfalls in routine practice and hybrid treatment methods, but was unable to reveal many aspects of daily practice. Indeed, many particular situations such as total neoadjuvant treatment, CRM positivity, or utility of neoadjuvant CT regimens such as FOLFOXIRI were not fully explored. Furthermore, it was difficult to draw comparisons between groups as fewer radiotherapists and surgeons participated in the survey than medical oncologists. Also, high numbers of younger participants in the medical oncology group may have affected the results. This phenomenon was a result of an increased quota of

medical oncologists compared to surgical and radiation oncologists. Although there were significant difference in terms of experience, due to the longer education period for medical oncology in Turkey, this phenomenon may not have affected the results. Additionally, limited data in the literature comparing medical oncologists, radiation oncologists, and surgeons, made comparison with other studies difficult.

Conclusions

We found that the new pre-operative CT regimen with short-course RT has been slowly adopted into current practice. Also, medical oncologists tended to implement pre-operative CT more often when compared with the other groups. Optimal surgery time for patients receiving neoadjuvant treatment remains controversial.

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PREVALENCE OF EXERCISE DEPENDENCE IN ROCK CLIMBERS AND MOUNTAINEERS

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Research on physical activity has extensively shown that regular exercise produces many physical and psychological benefits. However, excessively practiced physical activities can also have negative effects, both physical and psychological. One of them is the risk of becoming dependent on exercise, similar to substances such as drugs or alcohol. Most studies on exercise dependence have focused on runners and strength athletes.

Aim of the study: This study aimed to explore the prevalence of exercise dependence in climbers.

Material and methods: A group of 272 climbers (32.3±8.7 years old) participated in the study. They were divided into three groups: sport/rock climbers (59.6%), boulderers (30.2%), and mountaineers (10.3%). Data was collected using the Exercise Dependence Scale (EDS).

Results: Based on EDS scores, 44 climbers (16.2%) were classified as at-risk for exercise dependence, 183 (67.3%) as nondependent-symptomatic, and 45 (16.5%) as asymptomatic. Competitive and non-competitive climbers significantly differed in tolerance, and boulderers scored significantly higher than rock climbers and mountaineers.

Conclusions: Climbers are at risk of developing exercise dependence, especially those who participate in climbing competitions and who are boulderers. However, more research is needed to further characterize this phenomenon in the climbing community.

KEYWORDS: exercise dependence, behavioral addiction, climbing

Background

There is widespread agreement that physical activity is an essential factor in preventive health care and affects all of its dimensions – physical, social, and psychological [1]. Therefore, the World Health Organization (WHO) recommends regularly participating in moderate to vigorous aerobic exercises, supplemented by muscle-strengthening activities [2]. Climbing is considered to be one of those activities that can offer a wide range of health benefits [3,4], although empirical data on this is scarce. However, exercise can also be undertaken in an excessive and uncontrolled manner causing negative effects, including a set of symptoms described as exercise addiction, exercise dependence (ED), obligatory exercise, etc. [5,6].

For the person addicted to exercise, the activity becomes the essence of their life resulting in the elimination of other forms of leisure. The need for exercise conflicts with work, family, and social responsibilities, and even the health of the person when they continue to exercise despite an illness or injury. This phenomenon is accompanied by neuroadaptation which also occurs during addiction to psychoactive substances and can manifest itself with withdrawal symptoms (nervousness, irritability). Like other behavioral addictions (gambling, shopping, or the Internet), it often results in physical, psychological, and/or emotional harm [7]. Based on the criteria for substance dependence described in the Diagnostic and Statistical Manual of Mental Disorder-IV (DSM-IV), Hausenblas and Downs [8] developed the Exercise Dependence Scale (EDS) and proposed di-

agnostic criteria to distinguish ED from healthy exercise patterns. The risk of addiction was considered when a person scores high in at least three of the following criteria:

- Tolerance: a need for increasing amounts of exercise to achieve the desired effects.
- Continuance: continued exercise despite being aware of the problems caused by the exercise.
- Withdrawal: anxiety and tiredness experienced when the amount of exercise decreases resulting in the exercise being undertaken to relieve or avoid these sensations.
- Intention effect: exercise is performed in more significant amounts or more frequently than intended.
- Lack of control: inability to stop or reduce normal levels of commitment to exercise.
- Reduction of other activities: skipping occupational, family, social, other leisure activities (hobbies), and obligations in order to exercise.
- Time: excessive time spent on activities related to exercise activity (eg. planning, thinking about exercise).

Excessive exercise can be secondary to other disorders, mainly anorexia nervosa or bulimia nervosa, or primary when it is an end in itself [7,9]. The etiology of exercise addiction is not completely understood, nor is its prevalence in the population, mainly due to the lack of formal criteria and diversity of diagnostic tools. Some have been constructed that are specific to a particular form of activity (e.g. running), and even those that have a universal diagnostic dimension differ in how the addiction construct is operationalized, the number of items, etc. These factors coincide with the apparent variation of this phenomenon across populations, type of activity practiced, level of engagement, and other demographic characteristics. Taking the above into consideration, this phenomenon may affect 2% to 20% and in some studies up to 40% of people who exercise regularly [10,11,12,13, 14,15].

Studies of the prevalence of exercise addiction among athletes and regular exercisers have been carried out primarily in endurance (runners and triathletes) and power (bodybuilders and fitness center attendees) activities. Data on the prevalence of ED in climbers is scarce, and the specificity of this type of activity makes such estimates even more difficult. Climbing is a type of activity that is practiced in many ways, sometimes differing dramatically in the effort undertaken – intensity, volume, proportions of individual energy systems, the essence of the motor activity undertaken, etc. The most popular forms of climbing are bouldering, sport/rock climbing, and mountain climbing. The essence of bouldering is overcoming short, intense climbing routes called problems that are complex in movements and require strength or strength endurance. On the contrary, mountaineering is practiced on mountainous terrains and requires many hours of continuous effort in difficult weather conditions. Between these extremes, there is also sport/rock climbing on routes of different lengths and nature (e.g. depending on the angle of the climbing wall) and competition climbing on artificial climbing walls. Regardless of the type of climbing, its features, such as diversity of experiences, high emotional load, novelty, element of risk, and challenges, make these forms of activities a source of experiences rarely encountered in other areas of life and social situations [16]. These elements give climbing a strong pull and are factors that can shape a person's sense of identity [17, 18]. Exercise identity, in turn, is an essential determinant of exercise behavior, making individuals less likely to drop out. However, it can foster an addiction to the exercise that gave rise to this identity [5].

Aim of the study

Given the unknown extent of the phenomenon of exercise addiction in the climbing community, this study aimed to investigate the prevalence of exercise addictions within the climbing community in relation to the type of climbing with which climbers most strongly identify themselves.

Material and methods

Study design

Participants were invited to complete a survey via the internet. The questionnaire was distributed using the forum of the most popular web portal for climbers. Its broad subject matter means that it is followed by many climbers, representing different climbing varieties, which creates significant opportunities for our research to reach a wide range of participants.

Participants

Two hundred and seventy climbers, including 87 (32%) females (Mean age=32.3, Standard Deviation=8.7), were recruited using convenience sampling. According to the main type of climbing practiced by the participants, they were classified as sport/rock climbers (n=162, 59.6%), boulderers (n=82, 30.2%), and mountain climbers (n=28, 10.3%). Of these, 122 (44.9%) participants took part in climbing competitions (bouldering and/or lead). The numbers of the different groups of climbers varied with the smallest representation being mountain-

eers, although these proportions largely reflect the popularity of this type of climbing. The classification into individual categories was based on the respondents' declarations as to the climbing discipline they identified with to the greatest extent. Of course, it does not have to exclude the occasional practicing of other forms (e.g., climbing with a rope or bouldering by mountaineers). Competitive status was assessed by asking climbers whether they participated in climbing competitions (lead, bouldering). The mean experience in climbing was 7.8±7.3 years. Their climbing level was expressed by the greatest difficulties that they can overcome in the so-called RP style, i.e. without rest or falling, using the International Union of Alpine Associations (UIAA) scale (7.9±1.2) [19] and the French grading system (5 to 8c). A flowchart of the participants is present in Figure 1.

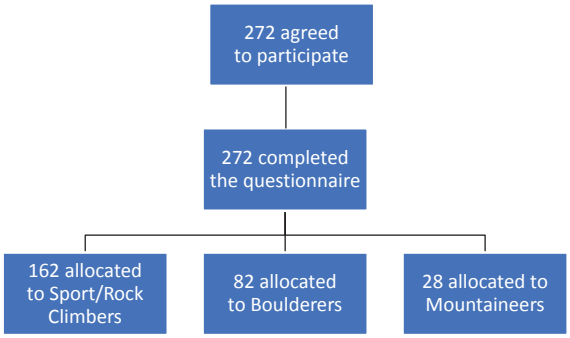

Figure 1. Flowchart of participants

Data collection

The Polish adaptation of the EDS developed by Hausenblas and Downs [11] was used to assess ED [20]. The EDS is comprised of 7 subscales, measuring seven criteria of dependence. Each subscale involves three statements rated on a 6-point Likert scale. Hausenblas and Downs [11] provided guidelines for interpreting EDS scores: individuals with scores averaging 5 or 6 for three or more subscales should be considered "at-risk" for ED, those with scores averaging 3 or 4 for three or more subscales are considered "nondependent symptomatic", and individuals with scores averaging 1 or 2 are classified as "nondependent asymptomatic". Cronbach's alfa values for the following symptoms were withdrawal (0.66), continuance (0.77), tolerance (0.74), lack of control (0.76), reduction of other activities (0.72), time (0.86), and intention (0.93). The skewness ranged from 0.02 (withdrawal) to 0.44 (reduction) and the kurtosis ranged from 0.35 (reduction) to -0.92 (continuance).

Statistical analysis

Descriptive statistics (means and standard deviations) were used to describe the data obtained. To test differences between nominal data a chi^2 test was used with Cramér's V statistic (V-value) to measure the effect size. It was assumed that a V-value under 0.30 signifies a small effect size (weak association between variables), a V-value between 0.30 and 0.50 indicates a medium effect size (moderate association), and a value above 0.50 signifies a large effect size (strong association). For interval level data, t-tests or one-way analysis of variance (ANOVA) were used to compare groups. As a measure of effect size, Cohen's *d* was used to describe the standardized mean difference between two variables. In assessing the relationship between dependency dimensions and continuous variables – age, climbing experience, and climbing level – regression analysis was used. A p-value of <0.05 was used to signify statistical significance. The results of the ANOVA tests were followed by post hoc comparisons, when appropriate, using the Tukey's test. All calculations were made using the Statistica program 13.0 (Statsoft PL).

Results

Based on EDS scores, 44 climbers (16.2%) were classified to be at-risk for ED, 183 (67.3%) as nondependent-symptomatic, and 45 (16.5%) as asymptomatic. There were no significant differences between male and female climbers classified as at-risk, nondependent-symptomatic, or asymptomatic (χ^2=3.0, p=0.22). A significant difference was observed between boulder, rock, and mountain climbers (χ^2=14.3, p=0.03, Cramer's V=16.2), with the former scoring higher (24% of at-risk) than the remaining two groups (rock climbers 12%, mountaineers 7%). The prevalence rates of the seven dimensions of ED in the participants are shown in Table 1.

Rock climbers and boulderers are internally diverse groups regarding their attitude towards direct competition in climbing. The variability in this respect ranges from those who concentrate their activity on natural rock (training on artificial walls in the off-season) to make more difficult ascents without confrontation with others, to those who strive for self-realization through both indirect and direct competition, to those who hardly climb in the outdoors, to those devoting all their time to taking part in climbing competitions. The participation in direct competitions has apparent ambition and motivational implications, but does this translate into a risk of addiction? As revealed in the comparison between climbers taking part in direct competitions to those who do not, the difference was not significant (χ^2=3.27, p=0.19). However, when comparing individual symptoms separately between competitive climbers and non-competitive climbers, they significantly differed in "tolerance" (χ^2=6.3, p=0.04,

Table 1. Participants classified by EDS scores as at-risk of exorcise dependence, nondependent-symptomatic, and nondependent-asymptomatic

Variable	Asymptomatic		Aymptomatic		Dependent	
	n	%	n	%	n	%
Withdrawal	61	22.4	163	59.9	48	17.4
Continuation	104	38.2	127	46.7	41	15.1
Tolerance	75	27.6	165	60.7	32	11.8
Control	101	37.1	141	51.8	30	11.0
Reduction in other activities	114	41.9	147	54.0	11	4.0
Time	65	23.9	133	48.9	74	27.2
Intention	103	37.9	110	40.4	59	21.7

Cramer's V=0.15) with the former scoring higher than the latter in terms of those at-risk (16.4% vs 8.2%).

Mean EDS scores are displayed in Table 2. In the entire sample, the highest mean was observed in "time" and the lowest in "the reduction of other activities". Regression models using age, climbing seniority, and level of advancement as predictors of individual dimensions of addiction were significant in relation to "intentionality" (R^2=0.08, $F_{(3.215)}$=6.20, p<0.001), "tolerance" (R^2=0.07, $F_{(3.215)}$=5.56, p=0.001), "loss of control" (R^2=0.03, $F_{(2.218)}$=3.35, p=0.04), and "time" (R^2=0.08, $F_{(3.215)}$=6.47, p<0.001). In all these cases, statistical significance was observed in relation to climbing seniority, which was a negative predictor, reaching values of the standardized β-coefficient from -0.17 (loss of control) to -0.30 (time). Therefore, these results suggest that the shorter the climbing experience, the greater the risk of exacerbating the dimensions of addiction – Table 2.

Table 2. Means and Standard Deviations for Exercise Addiction by gender, competitive experience, and type of climbing activity

Variable	Total sample	Gender			Competition			Climbing activity				
		Male	Female	p	Yes	No	p	B*	Sc*	M*	p	Post hoc
	M±SD	M±SD	M±SD		M±SD	M±SD		M±SD	M±SD	M±SD		
Withdrawal	3.4±1.2	3.6±1.1	3.3±1.2	.01	3.4±1.2	3.4±1.2	.68	3.5±1.1	3.4±1.2	3.4±1.2	.34	B>Sc. M*
Continuation	3.0±1.3	3.0±1.3	3.0±1.2	.68	3.2±1.2	2.9±1.3	.07	3.2±1.2	3.0±1.3	2.9±1.3	.32	
Tolerance	3.2±1.1	3.4±1.1	3.1±1.1	.06	3.4±1.1	3.1±1.1	.03	3.5±1.1	3.1±1.1	2.9±1.1	.01	
Control	3.0±1.2	3.1±1.2	2.9±1.2	.08	3.0±1.2	2.9±1.2	.62	3.2±1.2	2.9±1.2	2.6±1.1	.17	
Reduction in other activities	2.7±1.0	2.6±0.9	2.8±1.0	.11	2.7±1.0	2.7±0.9	.96	2.7±0.9	2.7±1.0	2.7±1.1	.99	
Time	3.6±1.3	3.7±1.2	3.5±1.3	.18	3.7±1.2	3.5±1.0	.07	3.6±1.3	3.6±1.3	3.3±1.3	.40	
Intention	3.2±1.4	3.5±1.5	3.0±1.3	.02	3.4±1.4	3.0±1.4	.06	3.3±1.4	3.1±1.4	3.2±1.2	.57	

* B – bouldering; Sc – sport climbing; M – mountaineering.

Discussion

The present study aimed to determine the prevalence of ED in climbers. To our knowledge, this study is one of the first to assess the prevalence of ED in people practicing various forms of climbing.

Previously, the only study on dependence in climbing we are aware of was conducted by Heirene et al. [21]. Unlike ours, it was rather qualitative. Using semi-structured interviews, the authors explored withdrawal experiences in four advanced and four intermediate male rock climbers during periods of abstinence from climbing. Their results demonstrated that advanced climbers recalled more frequent and intense cravings and negative effects during these periods than their less able counterparts.

In our research, we focused on the diagnosis of addiction among climbers, assuming the operationalization of this syndrome as proposed by Hausenblas and Downs [11], and therefore taking into account the dimensions of tolerance, continuing exercises despite problems, experiencing anxiety or tension while the exercise decreases (withdrawal), exercising longer than intended, lack of control overexercising, reducing other activities, and spending a significant amount of time on activities in preparation of exercise.

The results obtained show that of the 272 climbers, 16% (n=44) can be classified as being at-risk of ED while 67% (n=183) as nondependent-symptomatic. While the percentage of male and female climbers classified as at-risk, symptomatic, or asymptomatic

were similar, females reported significantly higher scores on the dimensions of intentional effect. They also tended to have higher average scores on the tolerance dimension (p=0.06). However, it should be emphasized that the effect sizes (d=0.37 and d=0.27, respectively) indicate that the difference between the two genders is rather small. Contrary to what was expected, no differences were observed between climbers who competed in the climbing contests from those who do not. We hypothesized that competition climbers would be more likely to develop an exercise addiction syndrome as they struggle with themselves and the challenges of the rock and other climbers at the same time. The obtained results did not confirm this assumption, except that competition climbers reported higher average scores on the tolerance scale. The percentage of players who met the at-risk classification criteria was double in this group (16.4% vs 8.2%). The risk of addiction was significantly higher in climbers who identified themselves as boulderers. The percentage of people specializing in this form of climbing was 24% compared to 12% among rock climbers and 7% among mountaineers.

The answer to how the surveyed climbers compare to other forms of activity and sports is difficult due to the far-reaching inconsistency of the results of various studies. Even when studies were conducted using the two tools that are considered well-validated, the Exercise Addiction Inventory (EAI) and the EDS [6]. In a recent review of the literature on this topic, Marques et al. [15] found that regular exercisers presented a prevalence of ED risk ranging from 1.9 to 42% and 1.4 to 17% in athletes. However, most studies presented results in the 6–17% range. In the remaining groups, such as high school students, sport shop customers, and the general population, the prevalence ranged from 0.3% (general population) to 29.6% (sports shop customers). In another review that aimed to compare ED across sports, di Lodovici et al [22] found a different distribution of addiction rates depending on whether it was diagnosed using EAI or EDS. The EAI identified the highest proportion of people at risk for physical exercise addiction in endurance athletes (14.2%), followed by ball games (10.4%), fitness center attendees (8.2%), and power disciplines (6.4%). In studies using the EDS, the highest proportion of risk was found in mixed disciplines/ball games (15.3%) followed by power sports (10.7%), health and fitness activities (6.0%), and endurance disciplines (3.5%). In studies in which the diagnosis of ED used other tools, including those specific to a given activity (mainly running and body-building), high prevalence rates were often found, sometimes as high as 77% in runner studies [4]. The discrepancies between EAI and EDS are primarily due to the differences in the internal structure of these tools. EAI evaluates 6 symptoms of addiction (tolerance, withdrawal, relapse, salience, conflict, and mood modification), each of which is assessed with one item. In comparison, EDS is based on DSM-IV and thus evaluates seven symptoms of addiction, each assessed with 3 items. Comparing the results of our research to studies that were conducted using EDS in athletes or people that regularly exercise, the climber community, in terms of the prevalence of ED, would be among the disciplines with a moderate to high addiction potential.

In contrast to other forms of activity, such as body-building and running, climbing offers intense emotional risk-related sensations that may satisfy the high sensation-seeking behavior found in drug users [21]. Thus, climbing and other extreme sports can stimulate the brain's reward system, similar to psychoactive substances, giving them an addictive quality. Climbing is also a sport that offers a great deal of variability. Each climbing route is different. Even on a given route, each capture is usually different from the previous one. The variability, lack of monotony, uniqueness of experiences, and constant satisfaction of the need for novelty is unique to climbing, whereas other spheres of life and other forms of physical activity become an area of routine monotony. Based on qualitative research conducted among climbers, Kacperczyk [16] points out that the admiration for a mountain or rocky road turns into a desire to conquer it, sometimes so strong that the climber experiences it as "an obliging and primary task, filling the entire field of attention and ruthlessly engaging". The obsession with a route is a kind of intense tension motivating the climber to conquer it and when accomplished to look for other similar challenges. These aspects can make an activity that engages people who climb to the point where "healthy" commitment turns into the above-mentioned "obsession". It can become all-consuming and be undertaken with disregard to illness/injury, inability to miss a climbing opportunity, risk of conflict with family/friends, etc. The present findings provide some novel insight into ED in a population of exercisers that was previously less explored.

Limitations of the study

However, there are some limitations to our study that have to be mentioned. First of all, comparisons between particular groups of climbers are biased due to their unequal numbers, especially the relatively low number of mountain climbers. This affects the possibility of making comparisons between the different groups. However, it is essential to remember

that the disparity in the size of the different groups of climbers reflects the popularity of the particular activities in real life. Another limitation affecting the possibility of generalizing the results of comparisons between the groups is the adopted method of classifying them. In the research, we adopted the participant's declaration of their "dominant identity". There are declared lovers of only one activity (e.g. boulder climbers who do not even have a climbing rope or other similar equipment, only climbing shoes and a chalk bag). However, many climbers practice two or more activities in parallel, with varying levels of involvement (e.g. bouldering and rock climbing, summer and winter mountain climbing). Similarly, some climbers mainly train to participate in competitions and participate almost without touching a natural rock. However, many rock climbers pursue their passions in nature.

Future research should be performed on larger groups and consider different groups and subgroups. Our study did not consider variables such as training frequency, which may also influence addiction. Because of the complex nature of exercise addiction and the equally complex nature of climbing, additional research is needed. Nevertheless, we believe that our study can contribute to future research of this type in the climbing environment.

Conclusions

Our data support the hypothesis that climbing may be a form of activity that can engage its enthusiasts so much that it can become an addiction. The probability of this occurrence is at least partly dependent on the climbing discipline, with bouldering being the most prominent risk factor. The reasons for this, however, are not obvious. While it can be assumed that the frequency of mountaineering is the lowest of the climbing activities (distance from the mountains, limitation to certain weather conditions, high logistical commitment, etc.), bouldering, due to the spread of artificial boulder walls, offers the highest frequency of contact with this type of climbing. It is also rock climbing that offers the greatest variety of movement and motor challenges. Whether it is these factors that lead to exposed people becoming addicted, should be sought and requires further research. We believe that our research can provide the basis for future research.

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THE INFLUENCE ON MENSTRUAL CYCLE PHASES ON TRUNK FLEXION MOBILITY ASSESSED WITH FINGER FLOOR DISTANCE TEST: A PRELIMINARY STUDY

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: The menstrual cycle plays an important role in a woman's body and the relationship between different phases of the menstrual cycle and flexibility has not been well known.

Aim of the study: This study aimed to examine whether the different phases of the menstrual cycle could affect trunk flexion mobility in young, healthy, physically active women who had not used hormonal contraception and had not received hormone treatment.

Material and methods: In total, ten healthy female nulliparas aged 25–30 participated in the study. The inclusion criterion for the study was regular menstruation (25–35 cycle days). The exclusion criteria were: hormonal treatment, use of hormonal contraception, BMI>25, and history of pregnancy. To assess trunk flexion mobility the finger floor distance test was used. The test was performed on each participant three times: during menstruation (follicular phase), during ovulation (ovulatory phase), and after day 15 of the cycle (luteal phase). Friedman ANOVA was used to determine the effect of the menstrual cycle phases on the finger floor distance test results. It was followed by Wilcoxon signed rank test.

Results: There was a significant effect of the phases of the menstrual cycle on the results of the finger floor distance test ($p=0.03$). Significantly higher values for the finger floor distance test result in the follicular phase as compared to the ovulatory phase were found ($p=0.02$).

Conclusions: The comparison of finger floor distance test results obtained in young healthy nulliparas in three phases of the menstrual cycle indicates decreased trunk flexion mobility in the follicular phase.

KEYWORDS: menstrual cycle, flexibility, trunk flexion mobility, finger floor distance test

Background

The presence of a menstrual cycle testifies to the sexual maturity of the female reproductive system and it enables procreation. It is possible thanks to hormonal changes which occur in specific phases of the cycle. The menstrual cycle consists of 3 phases: the follicular, ovulatory, and luteal. The normal menstrual cycle lasts from 21 to 35 days, the average of which are 28 days [1].

Depending on the phase of the cycle, the level of hormones in the circulating blood changes. In each phase, a different hormone dominates. Among other things, the ratio of hormones such as estrogens and progesterone influences the correct functioning of the female body. The early follicular phase is characterized by low levels of estrogens and progesterone, then these proportions change, and the amount of estrogens increases, while progesterone remains at a low level. In the middle of the luteal phase, both of these hormones assume high values [2].

Current knowledge of the impact of the menstrual cycle on physical fitness is diverse and incomplete. There are studies confirming the influence of particular phases of the menstrual cycle on the physical disposition of women [3,4,5]. The purpose of the one of the studies was to determine the effect of menstrual cycle phase and sex upon glucose turnover and muscle glycogen utilization during physical effort. The study group included 13 healthy, recreationally active young women and 11 men. The results of the research were as follows: women during the luteal phase had lower glucose rate of appearance and lower total glycogen utilization compared with women during follicular phase [3]. Another of the studies evaluated the impact of time of day and menstrual cycle phase on the determination of the lactate threshold and blood lactate concentration in response to physical exertion. The study group consisted of 11 endurance-trained female athletes. The results of the research showed that in the midluteal phase of the menstrual cycle specific lactate blood level occurred at a significantly higher exercise intensity, heart rate, and oxygen consumption than in the midfollicular phase [4]. Such knowledge is particularly useful regarding women training for competitive sports. Taking into account the physiology of physical effort, it has been found that parameters such as oxygen consumption, lactate threshold, plasma volume, hemoglobin concentration, and ventilation differ between phases of the menstrual cycle [5].

On the other hand, Loureiro et al. [1] assessed how muscle strength changed in the 10 repetition maximum (RM) test during different phases of the menstrual cycle. The test concerned measuring muscle strength during such movement tasks as leg press 45°, bench press, leg extension, and biceps curl [6]. The study group consisted of 9 healthy, physically active women. The authors of this study did not observe statistically significant differences in the results of this test depending on the menstrual cycle phase. Similar conclusions were reached by Weis et al. [7], the aim of their study was to investigate the range of motion (ROM) of extension at the fifth metacarpophalangeal joint and rotation of the cervical spine in women during the luteal and follicular phase of menstrual cycle. Sixteen nulliparous women were recruited to the research. The test results did not show a statistically significant correlation dependent on the cycle phase. The opposite conclusion was reached by Simao et al. [8] who observed a decrease in muscle strength during the first phase of the menstrual cycle compared to the other phases. The subjects were 19 physically active women. The strength was measured using the 8RM test, performing exercises for upper and lower body. A statistically significant difference was observed in the 45° leg press exercise during the first phase of the cycle compared to the other phases.

One of the physical fitness components is flexibility, which may be influenced by different phases of the menstrual cycle [9]. The American Council on Exercise defines flexibility as the range of motion in a joint or joints or the level of extensibility of a muscle group [10]. Flexibility depends on many factors, e.g.: gender, age, anatomical structure, body temperature, and time of day. With age, a decrease in flexibility is observed, which is partly related to the aging process of the body [11].

There are many ways to assess flexibility such as the flexibility test in the frontal plane [12], the finger floor distance test (FFD) [13], and the sit and reach test [14]. In addition, flexibility can be assessed using a goniometer [15].

Research findings on the effect of the menstrual cycle on flexibility in women are divergent. One study suggested that the different phases of the cycle do not interfere with soft tissue flexibility [14]. However, another study found greater hamstring muscle extensibility during the ovulatory phase compared to the follicular phase [9].

After searching databases (Pubmed, Ebsco, Google scholar) there are currently no systematic reviews related to the discussed topic. Therefore, there is a need for continuing research to further expand knowledge on this subject. This knowledge would be particularly valuable for coaches in competitive sports training and for planning studies on the assessment of motor skills in women. Knowing the influence of the menstrual cycle phases on flexibility would allow a more accurate selection of activities for women depending on their physical disposition.

Aim of the study

This preliminary study aimed to investigate whether particular phases of the menstrual cycle may impact trunk flexion mobility in young, healthy, physically active women who were not using hormonal contraception and were not hormonally treated. To assess the mobility of trunk flexion, the FFD test was selected as a reliable research tool [16,17]. It was hypothesized that the test results may differ between the phases of the menstrual cycle.

Material and methods

Sample

Ten healthy female nulliparas aged 25–30 participated in the study. The inclusion criterion for the study was regular menstruation (25–35 cycle days). The exclusion criteria were: hormonal treatment, use of hormonal contraception, BMI> 25, and history of pregnancy. The study participants were recruited from among the Academy of Physical Education students.

Before starting the study, the women were interviewed about their age, the length of their menstrual cycle, and their physical activity level. All were physically active (exercising in the gym and/or attending fitness classes at least once a week). Subject body mass and height were also measured and the body mass index (BMI) was calculated (Table 1).

Methods

The FFD test was used to assess trunk flexion mobility [16,17]. The test was performed on each woman three times: during menstruation (follicular phase), during ovulation (day 10–14 of the cycle), and after day 15 of the cycle (luteal phase). Each examination session took place at the same time of the day. For the FFD test, the subject stood on the stepper (10cm high) with her feet hip-width apart; successively, she was asked to raise her upper limbs with her elbows extended and then to bend forward, starting with a slow flexion of the cervical, and then subsequent sections of the spine. The knee joints remained extended. The women were instructed that the movement should be natural, unforced, and not be deepened. A measuring tape was used to measure the distance from the end of the longest finger of the right hand to the upper edge of the stepper. The upper edge of the stepper was a value of 0 (Figure 1). If the woman reached below the height of the upper edge of the stepper, the distance was recorded in negative values, and if she did not reach the upper edge of the stepper – it was recorded in positive values.

Ethics

This study was carried out as a part of a research project approved by the University Bioethics Committee. Before starting the research, all participants were explained their purpose and course. They gave their consent to carry out the research.

Statistical analysis

To find out whether the phases of the menstrual cycle had an effect on the FFD test result, a non-parametric repeated measure test – Friedman ANOVA – was used. As the result of the analysis was statistically significant, the Wilcoxon signed rank test was then performed. It allowed determining between which

Table 1. Characteristics of 10 young healthy, regularly menstruating women*

Subject	Age [years]	Body mass [kg]	Body height [cm]	BMI	Cycle length [days]
1	30	64	165	23.51	30
2	25	65	164	24.17	30
3	25	64	165	23.51	28
4	26	54	163	19.95	30
5	29	55	157	22.31	31
6	26	55	172	18.59	28
7	29	53	169	18.56	28
8	25	67	164	24.91	28
9	29	73	172	24.68	28
10	27	58	165	21.30	30
Average±SD** (median)	27.1±1.97 (26.5)	60.8±6.73 (61)	165.6±4.48 (165)	22.1±2.43 (22.9)	29.1±1.2 (29)

* Individual and average values.
** SD – standard deviation.

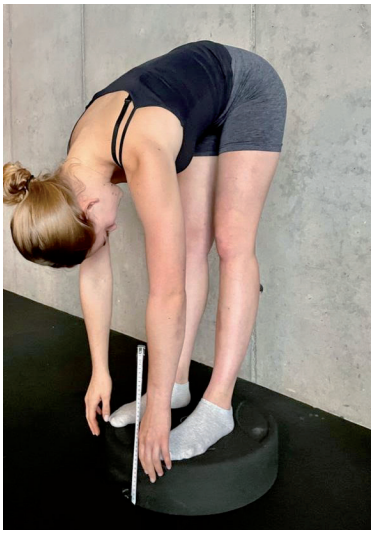

Figure 1. The participant of the study during the assessment of the mobility of the trunk flexion with the FFD test

phases of the cycle there were significant differences in trunk flexion mobility assessed with the FFD test.

The level of significance was set at $p<0.05$. Analyses were performed using Statistica v.13 (TIBCO Software, Palo Alto, CA, USA).

RESULTS

Out of approximately 20 screened patients, 10 were included in the study and statistical analysis (Figure 2). Table 2 shows the individual FFD test results for the three phases of the menstrual cycle. Friedman's ANOVA showed a significant effect of the phases of the menstrual cycle on the results of the FFD test (p=0.03).

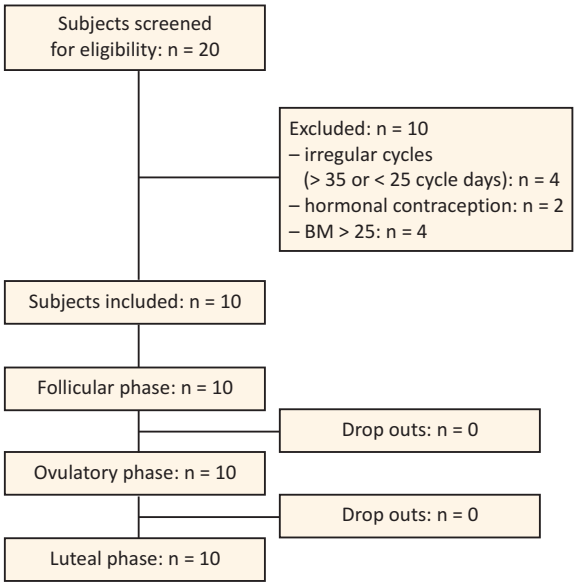

Figure 2. Study flowchart

Table 2. Individual and average results of the finger floor distance (FFD) test in 10 young regularly menstruating women at three phases of their menstrual cycles

Subject	FFD (cm)		
	Follicular phase	Ovulatory phase	Luteal phase
1	11	8	14
2	–2	–1.5	–4.5
3	14	12	13
4	8.5	6	8
5	5.5	4.5	5
6	–3	–2	–3
7	–1	–2	–1.5
8	5	3.5	3
9	8.5	4	5
10	11	8.5	9.5
Average±SD*	5.8±5.97	4.1±4.79	4.9±6.45

* SD – standard deviation.

The Wilcoxon test showed statistically significant differences in the FFD test results between follicular and ovulatory phases of the menstrual cycle. It indicates significantly higher values for the FFD test result ("worse" trunk flexion mobility) in the follicular phase as compared to the ovulatory phase (p=0.02, Figure 3).

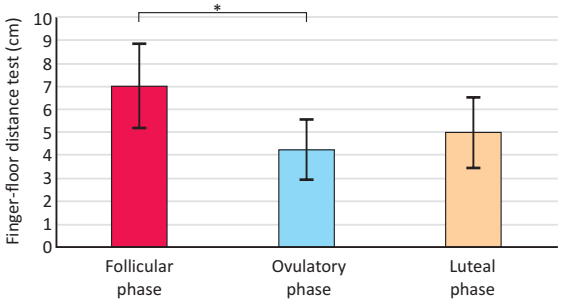

Figure 3. The results of the finger floor distance test in 10 young regularly menstruating women in the three phases of their menstrual cycle – medians and standard deviation
* p=0.02 (Wilcoxon test)

DISCUSSION

This preliminary study was an attempt to determine if the particular phases of the menstrual cycle may affect trunk flexion mobility assessed by the FFD test in young, healthy, physically active, hormonally untreated, and not using contraception women. The study was aimed at finding out whether the results of the FFD test differ depending on the phase of the cycle, and if so, in which phase trunk flexion mobility is the highest, and in which phase it is the lowest.

The statistical analysis revealed significantly higher values of the FFD test results in the follicular compared to the ovulatory phase. The results thus indicate that trunk flexion mobility was decreased in young women in their follicular phase of menstruation. However, the differences between the follicular and luteal phases, and the ovulatory and the luteal phases proved to be statistically not significant. Lower trunk flexibility in the follicular phase compared to the ovulatory phase may be related to the levels of estrogens and progesterone and their different ratio in these two menstrual phases.

Estrogen levels may influence connective and muscle tissues, an example of which is the postmenopausal lowering the level of these hormones resulting in a decrease in muscle mass [18]. Hawett [19] indicates that changes in female hormones are the main reason for ligament relaxation and decreased neuromuscular efficiency. Another study indicates that the elasticity of the anterior cruciate ligament is significantly higher during ovulation and pregnancy, when the level of estrogens increases [20,21]. Changes in the

level of estrogens and progesterone affect collagen metabolism which influences the properties of ligaments [22,23]. This could explain how the changes in hormone levels between follicular and ovulatory phases of the menstrual cycle may affect trunk flexibility which was assessed in the present study.

Our results are consistent with the study by Bell et al. [9] which indicates higher hamstring extensibility during ovulation in comparison to the follicular phase. The authors conducted research on eight premenopausal, not using contraception and regularly menstruating women. They measured hamstring extensibility and active muscle stiffness using a goniometer and reported that hamstring extensibility increased during ovulation and active muscle stiffness showed no changes. It was concluded that hamstring extensibility may depend on the level of estrogens in particular phases of the cycle. Campa et al. [24] in their study also observed decreased hamstring extensibility during the follicular phase in 20 female footballers. In contrast, Melagario et al. [15] suggested that particular phases of the cycle did not affect soft tissue flexibility. They conducted research on 20 women, aged 18–35, practicing gymnastics in fitness centers. The flexibility was evaluated by the goniometry measuring the range of motion of the shoulder, elbow, hip, knee, and low back in three phases of the menstrual cycle. The results of their study indicate that there were no significant differences in flexibility between individual phases of the menstrual cycle. The research results of Teixeira et al. [14] conducted on 40 women, aged 18–40, who regularly menstruated, and did not use contraception, also indicate no differences in flexibility between the follicular, the luteal, and the ovulatory phases. The younger age of our research group and the use of different measurement tool might be the reason that our findings are different than those of this research. Divergent reports on the influence of the menstrual cycle phases on flexibility indicate the need for further research in this area. The level of physical activity, age and history of pregnancy should be taken into account in the selection criteria for inclusion in future research.

Limitations

The limitation of the present study is a relatively small sample size, therefore, the results should be considered with caution. Future studies should be carried out on a larger sample and asses flexibility also within other parts of the female body.

Conclusions

The values of the FFD test results in young healthy nulliparas were higher in the follicular compared to the ovulatory phase of the menstrual cycle. This indicates that trunk flexion mobility was decreased in their follicular phase.

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