

DAUGAVPILS UNIVERSITĀTE
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DAUGAVPILS UNIVERSITĀTES ZINĀTŅU DAĻA
SCIENCE DEPARTMENT OF DAUGAVPILS UNIVERSITY

**DAUGAVPILS UNIVERSITĀTES
65. STARPTAUTISKĀS ZINĀTNISKĀS
KONFERENCES RAKSTU KRĀJUMS**

**PROCEEDINGS OF THE
65th INTERNATIONAL SCIENTIFIC
CONFERENCE OF DAUGAVPILS UNIVERSITY**

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PART A. NATURAL SCIENCES

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Daugavpils Universitātē docētāju un studējošo zinātniskās konferences notiek kopš 1958. gada. Konferencēm ir starpdisciplinārs raksturs un tajās piedalās gan studējošie, gan docētāji, gan arī ievērojami zinātnieki no dažādām pasaules valstīm. Daugavpils Universitātes 65. starptautiskās zinātniskās konferences pētījumu tematika bija ļoti plaša – dabas, veselības aprūpes, humanitāro un mākslas un sociālo zinātņu jomās.

Zinātnisko rakstu krājumā *Daugavpils Universitātes 65. starptautiskās zinātniskās konferences rakstu krājums = Proceedings of the 65th International Scientific Conference of Daugavpils University* apkopoti 2023. gada 20.–21. aprīlī konferencē prezentētie materiāli.

Daugavpils Universitātes 65. starptautiskās zinātniskās konferences rakstu krājums tiek publicēts 3 daļās: A. daļa. *Dabaszinātnes*; B. daļa. *Sociālās zinātnes*; C. daļa. *Humanitārās zinātnes*.

The annual scientific conferences at Daugavpils University have been organized since 1958. The themes of research presented at the conferences cover all spheres of life. Due to the facts that the conference was of interdisciplinary character and that its participants were students and outstanding scientists from different countries, the subjects of scientific investigations were very varied – in the domains of natural sciences, health care science, the humanities and art, and social sciences.

The results of scientific investigations presented during the conference are collected in the collection of scientific articles *Proceedings of the 65th International Scientific Conference of Daugavpils University*.

Proceedings of the 65th International Scientific Conference of Daugavpils University are published in three parts: part A. *Natural Sciences*; part B. *Social Sciences*; part C. *Humanities Sciences*.

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VESELĪBAS APRŪPES ZINĀTNE / HEALTH CARE SCIENCE

CLINICAL FEATURES, TREATMENT OUTCOMES AND PROGNOSTIC FACTORS IN ADULT PATIENTS HOSPITALIZED WITH SARS-COV-2 INFECTION: A RETROSPECTIVE COHORT STUDY

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Abstract

Clinical features, treatment outcomes and prognostic factors in adult patients hospitalized with SARS-CoV-2 infection: a retrospective cohort study

Key Words: SARS-CoV-2, comorbidities, mortality, laboratory parameters

Introduction: Since the first case of SARS-CoV-2 was reported in 2019, the coronavirus disease has been at the center of human attention. It can be asymptomatic, but in some cases it can cause severe pneumonia and then death.

Materials and methods: The aim of this study was to investigate the profile of comorbidities as well as clinical and laboratory parameters in Covid-19 patients to determine factors associated with higher mortality and more severe course of the disease. To achieve the goal, the medical histories of 410 patients were retrospectively analyzed. Statistical data analysis was performed with IBM SPSS program.

Results: It was found that generalized atherosclerosis increases the risk of mortality by 1.9 times, diabetes mellitus by 1.6 times, while chronic cerebral ischemia, encephalopathy and dementia by 3 times. Mortality is also higher in patients with chronic heart failure, atrial fibrillation, a history of cerebral infarction and diseases of the digestive system. Elevated levels of troponin T, D-dimer, C-reactive protein, lactate dehydrogenase, glucose, creatinine, urea, AST, ferritin, INR, erythrocyte sedimentation rate, and leukocytes are associated with worse disease outcome.

Conclusions: This study allows to identify the factors that predispose to a more severe course of Covid-19, thus filling the gaps in the literature on the coronavirus disease in the regional hospital of Latvia.

Kopsavilkums

Klīniskais raksturojums, ārstēšanas rezultāti un prognostiskie faktori pieaugušiem pacientiem, kas tika stacionēti ar SARS-CoV-2 infekciju: retrospektīvs kohortas pētījums

Atslēgvārdi: SARS-CoV-2, blakus slimības, mirstība, laboratorie parametri

Ievads: Kopš 2019. gada, kad tika ziņots par pirmo SARS-CoV-2 saslimšanas gadījumu, koronavīrusa slimība ir bijusi cilvēku uzmanības centrā. Tā var noritēt asimptomātiski, taču dažos gadījumos var izraisīt smagu pneimoniju un rezultātā arī nāvi.

Materiāli un metodes: Šī darba mērķis bija izpētīt blakus slimību, kā arī klīnisko un laboratorisko parametru profilu pacientiem ar SARS-CoV-2 infekciju, lai noteiktu faktorus, kas saistīti ar lielāku mirstību un smagāku slimības gaitu. Lai sasniegtu mērķi, tika retrospektīvi analizētas 410 pacientu slimības vēstures. Statistisko datu analīze tika veikta ar IBM SPSS programmu.

Rezultāti: Tika atklāts, ka ģeneralizēta ateroskleroze palielina mirstības risku 1.9 reizes, 2. tipa cukura diabēts – 1.6 reizes, savukārt hroniska cerebrāla išēmija, encefalopātija un demence 3 reizes. Lielāka mirstība ir arī pacientiem ar hronisku sirds mazspēju, ātriju fibrilāciju, cerebrālu infarku anamnēzē un gremošanas sistēmas slimībām. Paaugstināts troponīna T, D-dimēru, C-reaktīvā olbaltuma, laktātdehidrogenāzes, glikozes, kreatinīna, urīnvielas, ASAT, ferritīna, INR, eritrocītu grimšanas ātruma un leukocītu līmenis ir saistīts ar sliktāku slimības iznākumu.

Secinājumi: Šis pētījums ļauj identificēt faktorus, kas predisponē smagākai Covid-19 slimības norisei, tādējādi aizpildot literatūras trūkumus par koronavīrusa slimību Latvijas reģionālajā slimnīcā.

Introduction

In late December 2019, several cases of pneumonia of unknown origin were reported in China. In early January 2020, it was announced that they were caused by a new coronavirus called severe

acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Despite intensive, large-scale attempts to contain the spread of the disease, the virus has spread throughout the world in record time, and in March 2020, the World Health Organization declared the disease Covid-19 a pandemic (Ludwig, Zarbock 2020).

There are three known modes of transmission of the virus: contact transmission, droplet transmission and airborne transmission (Robles-Romero et al. 2022). Early symptoms of SARS-CoV-2 infection include fatigue, fever, dry cough, and anosmia. In about 80% of cases, the symptoms of the disease are mild and self-limiting, and they mainly affect the upper respiratory tract. Severe infection, characterized by shortness of breath, tachypnea, hypoxemia, as well as the development of pneumonia and involvement of the cardiovascular system, occurs in 15% of cases. Critical infection, characterized by respiratory failure, septic shock, multiple organ dysfunction syndrome, and often complicated by acute respiratory distress syndrome (ARDS), occurs in 5% of cases (Kaye et al. 2021).

The coronavirus, like other RNA viruses, is capable of genetic evolution. The virus is able to adapt to the human body, so new mutations are formed over time, and new variants of the virus appear, the exact clinical course, severity and complications of which are still not fully understood (Aleem et al. 2022, Fitero et al. 2022). Previous studies related to other similar viral infections, such as Middle East Respiratory Syndrome (MERS), emphasize that patients with diseases such as hypertension, cardiac disorders, diabetes, cancer, respiratory diseases, kidney disorders, adiposity, alcoholism and dementia is at increased risk of severe SARS-CoV-2 infection (Bigdelou et al. 2022, Fitero et al. 2022). Abnormal levels of laboratory markers such as C-reactive protein (CRO), D-dimer, lactate dehydrogenase (LDH), interleukin-6 (IL-6), and fibrinogen have been reported to correlate with disease severity (Damiati et al. 2022).

This pandemic has caused significant problems worldwide, and our understanding of this disease continues to evolve (Long et al. 2022). Uncertainty about which factors are associated with a higher risk of mortality and a more severe disease course often prolongs hospitalization (Trujillo-Rodriguez et al. 2022). Patients who have, for example, comorbidities are at a higher risk of developing a severe form of SARS-CoV-2 infection (Bigdelou et al. 2022). Studies are needed to evaluate the diagnostic effectiveness of different combinations of comorbidities as well as specific clinical and laboratory parameters. This can not only improve the effectiveness of treatment, but also reduce the economic burden by developing new practical considerations and recommendations related to SARS-CoV-2 infection (Bigdelou et al. 2022, Fitero et al. 2022).

Therefore, to fill the gaps in the literature on coronavirus disease in a regional hospital in Latvia, the aim of this work was to investigate the profile of comorbidities, as well as the clinical and laboratory parameters of patients who were hospitalized in Jelgava city hospital in the period from

08.11.2020. until 30.01.2021 with SARS-CoV-2 infection to determine factors associated with higher mortality and more severe disease course.

Material and methods

A retrospective cohort study was conducted in which the medical histories of 410 patients were analyzed. Medical histories of patients who were hospitalized in Jelgava city hospital between 08.11.2020 and 30.01.2021 and for whom SARS-CoV-2 infection was laboratory confirmed were selected from the hospital archive. All patients were grouped into three groups - dead, transferred to another hospital and discharged. The study included information on patients' age, gender, vital signs and symptoms at admission, as well as comorbidities, results of laboratory and radiological analyses. The obtained data were collected in MS Excel program and statistical data analysis was performed with IBM SPSS program using Kruskal-Wallis test, Fisher test, ROC curves and Cox proportional hazard regression. A significance level (p value) of <0.05 was considered significant.

Results

Of the 410 patients, 236 (57.6%) were women and 174 (42.4%) men. The median age was 71 years (IQR: 58-81). 105 (25.6%) patients died, 45 (11%) were transferred to another hospital and 260 (63.4%) were discharged. The median number of days spent in hospital was 7 days. The median time between onset of symptoms and laboratory confirmation of SARS-CoV-2 infection was 5 days.

Out of 410 patients, the condition of 272 patients after examination in the department was described as moderate, 40 patients were in a severe condition, 10 patients were in a very severe condition. In the admissions department, vital signs were determined for all patients: median of saturation was 95% (IQR: 90-97), respiratory rate - 18 x/min (IQR: 16-20), temperature - 37°C (IQR: 36.6-37.8), systolic pressure - 136 mmHg (IQR: 120-150), diastolic pressure – 80 mmHg (IQR: 70-90), heart rate – 90 x/min (IQR: 78-100). The most common clinical symptoms observed in patients were increased body temperature (67.8%), weakness (53.2%), cough (38.8%), shortness of breath (36.1%). Comparing the frequency of symptoms among discharged, transferred and deceased patients, it was found that symptoms such as weakness and shortness of breath are associated with higher mortality - shortness of breath was observed in 49.5% of the deceased (p=0.004), weakness - in 65.7% (p=0.009). Out of 410 patients, 139 patients had no pathological changes in the lungs. Among the patients who died despite the applied treatment, bilateral pneumonia was most often diagnosed - in 69 (65.7%) people. The clinical characteristics of SARS-CoV-2 patients at admission are shown in Table 1.

Table 1. **Characteristics of SARS-CoV-2 patients at admission**

Categories	Total	Dead	Transferred	Discharged	p-value
	(n = 410, 100%)	(n = 105, 25.6%)	(n = 45, 11%)	(n = 260, 63.4%)	
General condition at admission, n (%)					< 0.001

Satisfactory	88 (21.5)	0	13 (28.9)	75 (28.8)	
Moderately heavy	272 (66.3)	70 (66.7)	30 (66.7)	172 (66.2)	
Heavy	40 (9.8)	28 (26.7)	1 (2.2)	11 (4.2)	
Very heavy	10 (2.4)	7 (6.7)	1 (2.2)	2 (0.8)	
Vital signs at admission, median (IQR)					
Saturation (without O ₂)	95 (90-97)	89 (81-95)	96 (91-98)	96 (93-97)	< 0.001
Respiratory rate	18 (16-20)	19 (17-22)	16 (16-20)	17 (16-20)	< 0.001
Temperature, °C	37 (36.6-37.8)	37 (36.6-37.8)	36.8 (36.4-37.4)	37 (36.6-37.7)	0.073
Systolic blood pressure	136 (120-150)	134 (117-150)	136 (125-150)	136 (120-147)	0.776
Diastolic blood pressure	80 (70-90)	79 (70-87)	80 (74-89)	80 (70-90)	0.170
Heart rate	90 (78-100)	98 (82-114)	88 (73-100)	88 (78-100)	0.002
X-ray or computed tomography findings, n (%)					
Without pathology	139 (33.9)	18 (17.1)	26 (57.8)	95 (36.5)	< 0.001
Bilateral pneumonia	199 (48.5)	69 (65.7)	10 (22.2)	120 (46.2)	
Right sided pneumonia	41 (10)	12 (11.4)	4 (8.9)	25 (9.6)	
Left sided pneumonia	31 (7.6)	6 (5.7)	5 (11.1)	20 (7.7)	
Symptoms, n (%)					
Asymptomatic	71 (17.3)	17 (16.2)	13 (28.9)	41 (15.8)	0.113
Cough	159 (38.8)	22 (21)	11 (24.4)	126 (48.5)	< 0.001
Runny nose	10 (2.4)	0	1 (2.2)	9 (3.5)	0.115
Headache	30 (7.3)	5 (4.8)	2 (4.4)	23 (8.8)	0.361
Increased body temperature	278 (67.8)	69 (65.7)	27 (60)	182 (70)	0.360
Anosmia and ageusia	21 (5.1)	10 (9.5)	2 (4.4)	9 (3.5)	0.064
Neck pain	3 (0.7)	0	0	3 (1.2)	0.690
Weakness	218 (53.2)	69 (65.7)	20 (44.4)	129 (49.6)	0.009
Shortness of breath	148 (36.1)	52 (49.5)	14 (31.1)	82 (31.5)	0.004
Diarrhoea	24 (5.9)	5 (4.8)	2 (4.4)	17 (6.5)	0.856
Vomiting	26 (6.3)	4 (3.8)	0	22 (8.5)	0.044
Nausea	55 (13.4)	11 (10.5)	5 (11.1)	39 (15)	0.510
Muscle pain	21 (5.1)	4 (3.8)	0	17 (6.5)	0.154
Chest pain	27 (6.6)	9 (8.6)	2 (4.4)	16 (6.2)	0.656

After laboratory confirmation of the SARS-CoV-2 infection, patients underwent blood tests within 24 hours. The deceased patients were found to have elevated levels of D-dimers, erythrocyte sedimentation rate and minor leucocytosis. Biochemical rates also showed changes in patients who died: ferritin - median 995 ng/ml (p<0.001), AST - median 70 U/L (p<0.001), lactate dehydrogenase - median 518 U/L (p=0.002), urea - median 12.2 mmol/L (p<0.001), creatinine - median 188.5 umol/L (p<0.001), C reactive protein - median 101.2 mg/L (p<0.001), troponin T – median 84 pg/ml (p<0.001) and glucose – median 9.69 mmol/L (p<0.001). The findings of laboratory examinations are summarized in Table 2.

Table 2. Values of hematological, hemostasis and biochemical indicators depending on treatment outcome

Categories	Total	Dead	Transferred	Discharged	p-value
	(n = 410, 100%)	(n = 105, 25.6%)	(n = 45, 11%)	(n = 260, 63.4%)	
Laboratory analyses, median (IQR)					
Red blood cells, 10e12/L (n = 403)	4.49	4.48	4.26	4.50	0.101
Hemoglobin, g/DL (n = 403)	13.40	13.00	13.55	13.50	0.271
Hematocrit, % (n = 403)	38.00	37.70	38.55	38.15	0.719
White blood cells, 10e9/L (n = 403)	7.67	9.93	7.55	6.50	< 0.001

Platelets, 10e9/L (n = 403)	209.00	210.00	226.50	206.00	0.833
ESR, mm/h (n = 357)	24.00	35.00	25.00	20.00	< 0.001
INR (n = 192)	1.09	1.21	1.14	1.05	< 0.001
Prothrombin,% (n = 192)	84.00	69.00	76.00	90.00	< 0.001
D-dimers, mg/L (n = 306)	1.17	3.08	1.39	0.96	< 0.001
Ferritin, ng/ml (n = 230)	510.30	995.00	498.09	418.31	< 0.001
Total bilirubin, umol/L (n = 278)	9.90	11.30	11.60	9.20	0.009
Direct bilirubin, umol/L (n = 279)	4.80	7.00	5.60	4.20	< 0.001
ALT, U/L (n = 361)	29.00	31.00	29.00	28.00	0.428
AST, U/L (n = 313)	34.00	70.00	31.50	29.00	< 0.001
Lactate dehydrogenase, U/L (n = 207)	326.00	518.00	308.00	280.00	0.002
Urea, mmol/L (n = 317)	6.70	12.20	7.60	5.40	< 0.001
Creatinine, umol/L (n = 387)	84.60	118.50	81.90	77.60	< 0.001
C reactive protein, mg/L (n = 384)	58.80	101.20	53.60	43.20	< 0.001
Procalcitonin, ng/ml (n = 12)	0.078	N	0.067	0.085	0.644
Troponin T, pg/ml (n = 239)	16.80	84.00	13.40	9.20	< 0.001
Na, mmol/L (n = 299)	140	143	139	139	< 0.001
K, mmol/L (n = 321)	4.20	4.50	4.30	4.10	0.008
Glucose, mmol/L (n = 335)	6.41	9.69	6.13	6.03	< 0.001
HbA1c,% (n = 42)	7.1	7.1	9.8	6.8	0.779
TSH, mIU/L (n = 54)	1.031	N	1.266	0.889	0.334

ROC curves were constructed to find out how high-quality and effective these laboratory metrics are in predicting patient mortality. Of the 16 laboratory parameters, 12 parameter elevations were found to be associated with higher mortality. The best predictive parameter for mortality was found to be troponin T, with a high specificity and sensitivity. D-dimers also showed high sensitivity and specificity. C-reactive protein showed high sensitivity, but slightly lower specificity. The results are shown in Table 3 and Figure 1.

Table 3. **ROC curve analysis of laboratory parameters**

Laboratory parameter	Limit value	Specificity	Sensitivity	AUC	95% CI	p-value
White blood cells	7.04 10e9/L	66.70%	78.90%	0.734	0.574-0.894	0.011
ESR	28 mm/h	71.40%	84.20%	0.831	0.706-0.956	< 0.001
INR	1,13	85.70%	84.20%	0.855	0.733-0.976	< 0.001
D-dimers	1.19 mg/L	85.70%	94.70%	0.919	0.814-1.000	< 0.001
Ferritin	648.13 ng/ml	66.70%	84.20%	0.759	0.604-0.915	0.005
AST	52 U/L	95.20%	73.70%	0.838	0.692-0.985	< 0.001
Lactate dehydrogenase	444.5 U/L	90.50%	78.90%	0.781	0.611-0.951	0.002
Urea	6.95 mmol/L	76.20%	89.50%	0.857	0.733-0.982	< 0.001
Creatinine	106.2 umol/L	95.20%	73.70%	0.848	0.711-0.986	< 0.001
C reactive protein	58.2 mg/L	66.70%	94.70%	0.857	0.740-0.975	< 0.001
Troponin T	26.05 pg/ml	95.20%	94.70%	0.972	0.929-1.000	< 0.001
Glucose	8.21 mmol/L	85.70%	79.80%	0.822	0.689-0.956	0.001

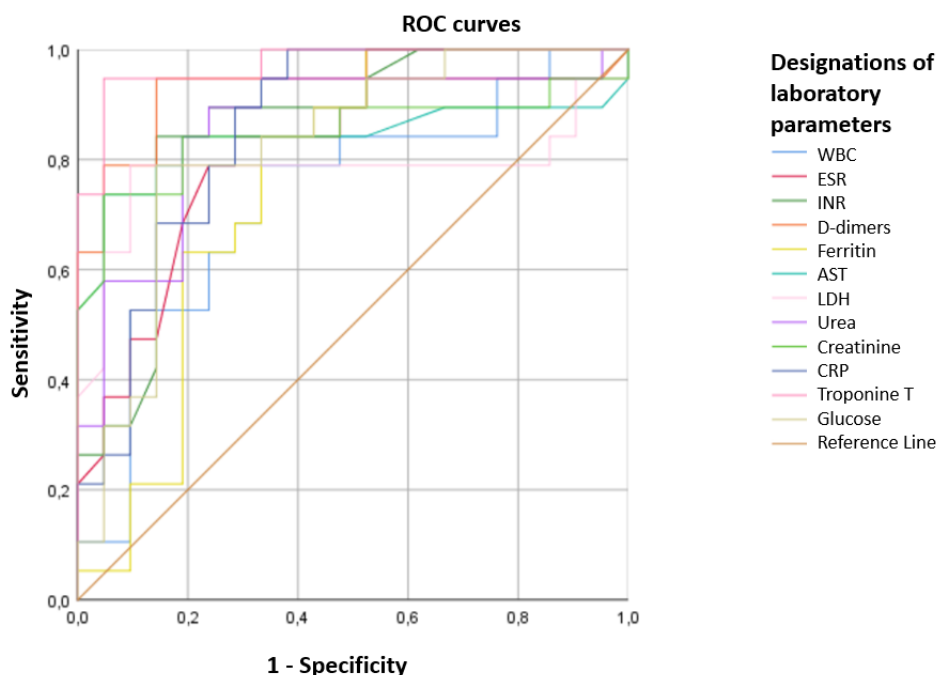


Figure 1. ROC curves for laboratory parameters associated with higher mortality

Comorbidities were seen in 358 (87.3%) patients, while 52 (12.7%) patients had no chronic illnesses. Most often, diseases of the cardiovascular system were found in patients. From this group of diseases, 222 (54.1%) people had arterial hypertension, 192 (46.8%) had chronic heart failure, 87 (21.2%) had atrial fibrillation, and 77 (18.8%) had generalized atherosclerosis. Only 41 people had diseases of the respiratory system. On the other hand, cerebrovascular diseases were found in 140 (34.1%) patients, and endocrine system diseases - in 118 (28.8%) patients, of whom 102 (24.9%) had type 2 diabetes. All comorbidities are summarized in Table 4.

Table 4. Incidence of comorbidities in SARS-CoV-2 patients depending on treatment outcome

Categories	Total (n = 410, 100%)	Dead (n = 105, 25.6%)	Transferred (n = 45, 11%)	Discharged (n = 260, 63.4%)	p-value
Comorbidity, n (%)					< 0.001
None	52 (12.7)	6 (5.7)	0	46 (17.7)	
One or more	358 (87.3)	99 (94.3)	45 (100)	214 (82.3)	
Cardiovascular diseases	275 (67.1)	77 (73.3)	31 (68.9)	167 (64.2)	0.240
Arterial hypertension	222 (54.1)	62 (59)	22 (48.9)	138 (53.1)	0.442
Chronic heart failure	192 (46.8)	62 (59)	24 (53.3)	106 (40.8)	0.004
Angina pectoris	48 (11.7)	16 (15.2)	4 (8.9)	28 (10.8)	0.431
Atrial fibrillation	87 (21.2)	30 (28.6)	14 (31.1)	43 (16.5)	0.007
History of myocardial infarction	46 (11.2)	17 (16.2)	7 (15.6)	22 (8.5)	0.058
Generalized atherosclerosis	77 (18.8)	34 (32.4)	8 (17.8)	35 (13.5)	< 0.001
Respiratory diseases	41 (10)	3 (2.9)	7 (15.6)	31 (11.9)	0.006
COPD ^b	11 (2.7)	0	1 (2.2)	10 (3.8)	0.095
Bronchial asthma	16 (3.9)	2 (1.9)	0	14 (5.4)	0.133
Chronic bronchitis	11 (2.7)	0	3 (6.7)	8 (3.1)	0.038
Lung cancer	4 (1)	1 (1)	1 (2.2)	2 (0.8)	0.419

Cerebrovascular diseases	140 (34.1)	56 (53.3)	26 (57.8)	58 (22.3)	< 0.001
Chronic cerebral ischemia, encephalopathy, dementia	94 (22.9)	46 (43.8)	16 (35.6)	32 (12.3)	< 0.001
Cerebral infarction history	62 (15.1)	23 (21.9)	11 (24.4)	28 (10.8)	0.005

Of the 28 comorbidity groups, statistically significant differences were found in 12 disease groups. In order to compare the effect of these comorbidities on survival, the hazard ratio was calculated for the variables that met all the criteria of the Cox regression. In the univariate model, a statistically significant hazard ratio was found for the three comorbidities, as well as for the age of the patients. Namely, when the age increases by one year, the risk of dying increases by 2.6%. Patients with generalized atherosclerosis have a 1.9-fold higher risk of death, and type 2 diabetes patients have a 1.6-fold higher risk of death. On the other hand, such diseases as chronic cerebral ischemia, encephalopathy and dementia increase the risk of mortality 3 times, this is also proven by multivariate analysis (adjusted by all factors in the table). The results are shown in Table 5.

Table 5. Cox regression analysis assessing comorbidities associated with higher mortality

Factor studied	Univariate		Multivariate	
	Unadjusted HR (95% CI)	p-value	Adjusted HR (95% CI)	p-value
Age (increasing by one year)	1.026 (1.010-1.042)	0.002	1.015 (0,997-1,034)	0.096
Gender	0.970 (0.657-1.432)	0.877	1.227 (0,812-1,857)	0.332
Chronic heart failure	1.325 (0.886-1.981)	0.171	0.807 (0,485-1,342)	0.408
Atrial fibrillation	1.213 (0.787-1.869)	0.381	0.874 (0,526-1,451)	0.526
Generalized atherosclerosis	1.907 (1.262-2.882)	0.002	1.118 (0,684-1,828)	0.656
Chronic cerebral ischemia, encephalopathy, dementia	2.957 (2.003-4.367)	< 0.001	2.522 (1,607-3,958)	< 0.001
Cerebral infarction history	1.223 (0.766-1.953)	0.400	1.114 (0,684-1,815)	0.665
Type 2 diabetes mellitus	1.621 (1.086-2.420)	0.018	1.691 (1,059-2,699)	0.028
Digestive system diseases	1.361 (0.848-2.187)	0.202	1.079 (0,664-1,754)	0.759

Discussion

This retrospective cohort study identified comorbidities, clinical and laboratory factors associated with treatment outcome in SARS-CoV-2 patients.

Of the 410 patients included in the study, 105 people died, corresponding to 25.6%. This indicator is slightly higher than in other European countries. The higher mortality rate can be explained by the fact that the study included data on patients treated for SARS-CoV-2 infection in the period from 30.10.2020 until 30.01.2021, when there were no guidelines for the treatment of this disease in Latvia, and many patients were brought in in a serious condition and died within one or two days. Procalcitonin levels were also not measured in many patients, so a larger patient group is needed to investigate the relationship of this parameter with mortality risk.

The effect of some comorbidities, such as chronic obstructive pulmonary disease, chronic bronchitis, bronchial asthma, lung cancer, as well as hypothyroidism, hyperthyroidism, alcoholism, and adiposity, on treatment outcomes was not possible to better evaluate because the number of patients with a particular comorbidity was insufficient to perform statistical tests (did not meet the prerequisites of Cox regression, as well as logistic regression and the Kaplan-Meier method).

Regarding other clinical and laboratory factors, as well as comorbidities, it can be concluded that the findings agree with the findings of other researchers, which indicates that the obtained results are reliable (Bigdelou et al. 2022, Damiati et al. 2022, Fitero et al. 2022, Trujillo-Rodriguez et al. 2022).

Conclusions

After retrospective data analysis and statistical processing, the factors influencing mortality risk and treatment outcome in SARS-CoV-2 patients have been identified. It was found that when age increases by one year, the risk of dying increases by 2.6%. Changes in laboratory parameters have also been found to be associated with disease outcome. Patients with elevated troponin T, D-dimers, C-reactive protein, lactate dehydrogenase, glucose, creatinine, urea, AST, ferritin, INR, erythrocyte sedimentation rate, and leukocytes had the highest mortality. Lower saturation, higher respiratory and heart rates at admission, as well as shortness of breath and weakness were also associated with higher mortality. An impact on disease outcome has X-ray and CT findings – radiologically diagnosed bilateral pneumonia was associated with a higher risk of death. It was discovered that comorbidities also have a significant impact on mortality risk. Patients with generalized atherosclerosis had 1.9 times (or 90.7%) higher risk of mortality. Type 2 diabetes patients had 1.6 times (or 62.1%) higher risk of death. On the other hand, such diseases as chronic cerebral ischemia, encephalopathy and dementia increased the risk of mortality 3 times (or by 95.7%).

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EFFECT OF STANDING SUPPORT CHAIR AND ANTI-FATIGUE MAT ON ELECTRIC ACTIVITY IN MUSCLES OF LEGS AND GLUTEAL REGION

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Abstract

Effect of standing support chair and anti-fatigue mat on electric activity in muscles of legs and gluteal region

Key Words: *Standing support chair, anti-fatigue mat, muscle electric activity, workplace intervention, prolonged standing, ergonomics*

Objectives: This study investigates lower leg and gluteal muscle electric activity while standing on a hard floor, office and industrial anti-fatigue mats, and using a standing support chair.

Methods and materials: 13 healthy volunteers stood for 20 min. in multiple scenarios. Muscle electric activity was measured bilaterally on *m.tibialis anterior*, *m.peroneus longus* and *m.gluteus medius* by surface electromyography with wireless electrodes (BTS FREEMG 1000, BTS Bioengineering) and analysed using a software provided by the manufacturer. A 1 min. sEMG recording was taken, then a 20-sec. artifact-free fragment was analysed using MS Excel and SPSS26.

Results: Lowest muscle activity occurred on the hard floor whereas standing on the office anti-fatigue mat results showed the highest muscle activity. The mean frequency of electric activity in *m.peroneus longus dx. et sin.* was 115.31Hz(108.26-135.52) and 110.14Hz(104.82-128.66) while standing on a hard floor, but standing on the office anti-fatigue mat activity peaked at 141.67Hz(121.29-152.56) and 134.82Hz(117.12-145.68)(p=0.001). To compare, the mean frequency of electric activity in *m.tibialis anterior dx. et sin.* were 115.91Hz(109.23-126.03) and 110.94Hz(104.37-134.52) on a hard floor, rising to 131.04Hz(122.88-140.70) and 141.82Hz(117.29-157.33) on the office mat(p=0.001). No statistically significant differences were found in gluteal muscle activity between standing on a hard floor and leaning against a standing support chair as well as comparing anti-fatigue mats to the standing support chair for lower leg muscles.

Conclusions: Muscles exhibit higher electric activity on softer surfaces, notably on an office anti-fatigue mat. Using a standing support chair there is a decrease in gluteal muscle activity compared to standing on hard and soft surfaces.

Kopsavilkums

Stāvkrēsla un pretnoguruma paklāju ietekme uz elektrisko aktivitāti apakšējo ekstremitāšu muskuļos

Atslēgvārdi: *Stāvkrēsls, pretnoguruma paklājs, muskuļu elektriskā aktivitāte, intervences darba vidē, ilgstoša stāvēšana, ergonomika*

Mērķis: Pētījumā tika analizēta apakšstilbu un sēžas muskuļu elektriskā aktivitāte stāvot uz cietas grīdas, biroja un industriāla pretnoguruma paklāja un izmantojot stāvkrēslu.

Metodes un materiāli: Pētījumā 13 veseli brīvprātīgie stāvēja 20 min. dažādos scenārijos. Muskuļu elektriskā aktivitāte tika mērīta abpusēji *m.tibialis anterior*, *m.peroneus longus* un *m.gluteus medius* izmantojot virsmas elektromiogrāfiju ar bezvadu elektrodēm (BTS FREEMG 1000, BTS Bioengineering). Dati tika analizēti, izmantojot speciālu ražotāja nodrošinātu programmu. Tika veikts 1 min. sEMG ieraksts no kura 20 sek. artefaktu nesaturošs fragments tika analizēts izmantojot MS Excel un SPSS26.

Rezultāti: Zemākā muskuļu aktivitāte bija uz cietas grīdas, taču, stāvot uz biroja pretnoguruma paklāja, tika konstatēta augstākā muskuļu aktivitāte. Vidējā elektriskās aktivitātes frekvence *m.peroneus longus dx. et sin.* uz cietas grīdas-115,31Hz(108.26-135.52) un 110.14Hz(104.82-128.66), stāvot uz industriālā pretnoguruma paklāja-125.58Hz(117.05-146.93) un 116.63Hz(112.04-132.15)(p=0.001), savukārt stāvot uz biroja pretnoguruma paklāja frekvence sasniedza maksimumu-141.67Hz(121.29-152.56) un 134.82Hz(117.12-145.68)(p=0.001). Salīdzinājumam, *M.tibialis anterior dx. et sin.* Vidējās elektriskās aktivitātes frekvences-115.91Hz(109.23-126.03) un 110.94Hz(104.37-134.52) uz cietas grīdas, pieaugot līdz 131.04Hz(122.88-140.70) un 141.82Hz(117.29-157.33) uz biroja pretnoguruma paklāja(p=0.001). Netika konstatētas statistiski nozīmīgas atšķirības muskuļu elektriskās aktivitātes frekvencēs stāvot uz cietas grīdas salīdzinājumā ar stāvēšanu atbalstoties pret stāvkrēslu, kā arī salīdzinot pretnoguruma paklājus ar stāvkrēsla izmantošanu apakšējo ekstremitāšu muskuļiem.

Secinājumi: Muskuļu elektriskā aktivitāte pieaug uz mīkstākām virsmām, īpaši uz biroja pretnoguruma paklāja. Stāvkrēsla izmantošana samazina sēžas muskuļu aktivitāti, salīdzinot ar stāvēšanu uz cietām un mīkstām virsmām.

Introduction

Recent studies have shown that standing for long periods on the same spot while working has been associated with several potentially serious health outcomes, such as lower back and leg pain,

cardiovascular and metabolic problems (*e.g.*, obesity), fatigue, and discomfort. Additionally, working in a standing posture on a daily basis can cause sore feet, swelling of the legs, varicose veins, general muscular fatigue and also stiffness in the neck and shoulders (Waters *et al.*, 2015). Prolonged and frequent standing, without some relief by walking or sitting, nowadays is common in many occupations such as workers in assembly lines, cashiers, food processing, teachers, soldiers, surgeons, office workers, hairdressers, nurses, and others (Zhang *et al.*, 2022).

Therefore, preventive workplace interventions like standing support chairs, hight adjustable desks, sit-stand workstations and anti-fatigue mats may come in handy. Static posture is associated with declining job performance, poor work engagement, occupational injuries and increased medical treatment costs. Thus, maintaining and improving workers' health could improve the vitality of employees, invigorate the workplace, and improve productivity (Ma *et al.*, 2021).

Within office settings and in workstations at home in recent years standing desks have risen in popularity. Research findings suggest that standing desks of different types (*e.g.*, height adjusted/stand-biased, individual/in group use) are an effective intervention to reduce sitting time while working or studying (Danilo *et al.*, 2018). Not only height adjustable desks are becoming more popular, but also walking desks or so-called treadmill desks. Standing and treadmill desks show good results for eliminating prolonged sitting and potentially improving aspects of health in younger and older individuals (Brittany *et al.*, 2015).

Another popular ergonomic intervention has been modifying the flooring in an attempt to alleviate the problems associated with prolonged standing. Besides shoe condition and standing time, floor type likely plays a role in discomfort while standing. Anti-fatigue mats are claimed to alleviate or reduce fatigue from standing, but there are a limited number of studies that prove their effectiveness. Although there is some evidence that matting materials can reduce physical discomfort and fatigue, it does not reduce the physiological effects of muscle fatigue (JoAnn *et al.*, 2004). Mats can be the solution for the workers to relieve muscle fatigue, however, there is not enough quantitative data available about mats and their characteristics that relieves leg and back fatigue (Yen-Hui *et al.*, 2012). The studies that have been done in the past hypothesize the central point that anti-fatigue mats increase lower leg muscle activity, so in result muscle contractions increase which activate venous pump and reduce discomfort in lower extremities (JoAnn *et al.*, 2004). Standing is not truly static. Due to gravity and the constant need to keep balance, a person's body sways in anterior-posterior and lateral directions, so shifting the weight from foot to foot provides an important pain relief mechanism. Anti-fatigue floor mats are designed to encourage the body's natural sway, stimulating subtle movement of the leg muscles (Ebben, 2003).

Study of military personnel which investigated material hardness, or cushioning, has identified that as a dominant factor for influencing footwear comfort (Mündermann *et al.*, 2001). Alternatively,

different standing interventions, such as the use of a standing aid, appropriate footwear or flooring, could potentially reduce muscle tension and pain (Kayla *et al.*, 2016).

So far there are not many studies that investigate how individuals' postural stability is affected by standing on rigid versus cushioned platforms but regardless of that many industries nowadays are investing in anti-fatigue mats at workstations to reduce and prevent fall, injury and discomfort. Some research has been done on the characteristics of thickness and stiffness of mats to determine the most beneficial properties. In general, softer materials tend to cause less perceived tiredness, however, extremely soft flooring results in higher ratings of tiredness. In conclusion harder flooring materials cause greater discomfort (Phyllis, 2002).

Another new ergonomic workplace improvement is a standing support chair. The idea of this intervention is to stimulate change of posture while working (Antle *et al.*, 2015), in addition it is recommended as an alternative to standing and sitting (Le *et al.*, 2016). A standing support chair is used while the person is in a standing posture. It must be adjusted to a necessary height and the main idea is to lean against it to reduce tension in lower leg muscles and lower back pain. A study shows that sit standing posture can reduce lower limb discomfort as well as improve vascular function better than a standing posture after sitting for a longer period of time (Antle *et al.*, 2015). A standing support chair also reduces tension in lower limbs when it is necessary to stand for longer periods of time in the workplace. Additionally, this intervention allows people to continue working without the need of changing their workplace (Smith *et al.*, 2000). Nevertheless, there is still lack of evidence to support the need and efficiency of a standing support chair in reducing discomfort, muscle tension and pain (Noguchi *et al.*, 2019).

Considering the results of previously mentioned studies, the aim of the current research was set to objectively investigate electric activity and, consequently, load in lower leg and gluteal muscles while leaning against a standing support chair, standing on an anti-fatigue mat (moderately soft industrial and softer office mat) compared to standing on a hard floor.

Materials and methods

The study involved 13 healthy 18-25 years young volunteers of whom 8 were females and 5 were males. The permission of the Research Ethics Committee of Rīga Stradiņš University (document number 2-PĒK-4/24/2022) was obtained to perform the following experimental study. The participation in the study was voluntary, participants were informed and instructed about the experiment process and had possibility to quit the study at any moment. All the data were processed in anonymous and coded way. Only healthy people without musculoskeletal pathologies were selected. Before the start, participants were questioned about recent traumas or possible muscle dysfunctions and all muscles involved in the study were tested using appropriate muscle tests by

Kendall (Kendall *et al.*, 2005) to exclude pathological functioning. Then, surface electromyography (sEMG) was used to determine muscle electric activity.

Four different scenarios were tested: 1) standing on a hard floor (control), 2) standing on an office anti-fatigue mat, 3) standing on an industrial anti-fatigue mat, and 4) while leaning against a standing support chair.

Research process

Muscles involved in the study were chosen by determining which ones participate most in the process of standing. There were muscles that were excluded from the selection because of the possibility of artefacts in the recordings due to cardiac activity and the pressure from the standing support chair.

After initial muscle testing with Kendall tests to exclude weak and dysfunctional muscles, skin was prepared by shaving off excess hair and cleaned with alcohol wipes. Electrodes were attached bilaterally to *m. tibialis anterior*, *m. peroneus longus*, and *m. gluteus medius* (further in the text *dx.* – right side, *sin.* – left side). The participant was asked to stand in front of a height-adjustable computer desk. The task was to imitate working on a computer by writing a text. The 20 minute standing time frame included an adaptation period. When the participant was comfortable and started writing the text, around the 14th minute a 1 minute long record of muscle electric activity was performed by sEMG. Then, the participant was given time to rest. The task and recording was repeated for four times testing different scenarios. Afterwards, data were exported and analysed.

The following equipment was used: electromyograph with wireless surface electrodes and manufacturer provided signal processing computer program (BTS FREEMG 1000, EMG Analyzer, BTS Bioengineering), office anti-fatigue mat, industrial anti-fatigue mat, standing support chair, height-adjustable table, computer, wi-fi router, disposable gel-coated electrode kit (certified for medical use in accordance with Regulation 93/42 / CEE as amended in 2007/47 / EC), a razor, alcohol wipes.

Data processing and analysis. Using BTS EMG Analyzer program, only a 20-second segment was cut from the one-minute EMG record with the smoothest possible measurement and no pronounced artifacts, from which the mean frequency (Hz) of electric activity was determined. The calculated values were tabulated using MS Excel, and then analysed statistically in the Statistical Package for the Social Sciences program version 26 (SPSS v. 26). The data were analysed according to non-normal distribution and using non-parametric tests (paired sample analysis, Wilcoxon signed-rank test, Mann-Whitney U test). Muscle electric activity changes were compared between individuals by muscles, on both sides, and by different scenarios. The significance level was set as $p < 0.05$.

Results

Data were obtained from 13 healthy participants. These data were collected and analysed to evaluate the effect of standing support adjustments and floor surface on lower leg and gluteal muscle electric activity. The visual summary of the data can be seen in Figure 1.

The lowest lower leg muscle activity was determined while standing on the hard floor. The mean frequency of electric activity in *m. peroneus longus dx. et sin.* while standing on the hard floor was 115.31 Hz (interquartile range Q1-Q3: 108.26-135.52) and 110.14 Hz (104.82-128.66) on the right and left side accordingly. Significantly higher frequency in the same muscle was observed while standing on the industrial anti-fatigue mat (125.58 Hz (117.05-146.93) and 116.63 Hz (112.04-132.15); $p=0.001$), and even higher while standing on the softer office anti-fatigue mat – 141.67 Hz (121.29-152.56) on the right side and 134.82 Hz (117.12-145.68) on the left side ($p=0.001$). On contrary, while leaning against a standing support chair, the frequency in this muscle was significantly lower (120.44 Hz (104.32-126.190) and 123.99 Hz (104.57-131.01); $p=0.814$ and $p=0.075$) than in case of anti-fatigue mats and similar to that in standing on a hard floor, but these electric activity changes were not statistically significant.

The mean frequency of electric activity in *m. tibialis anterior dx. et sin.* while standing on the hard floor was 115.91 Hz (109.23-126.03) on the right side and 110.94 Hz (104.37-134.52) on the left side, but on the soft office mat – 131.04 Hz (122.88-140.70), 141.82 Hz (117.29-157.33) accordingly ($p=0.001$). While standing on the softer office anti-fatigue mat, muscle activity in lower leg muscles was the highest among surfaces. The mean frequency of electric activity in *m. tibialis anterior* while standing on a harder industrial anti-fatigue mat was 126.14 Hz (118.66-131.83) on the right side and 132.43 Hz (113.29-155.51) on the left side and while leaning against a standing support chair similar results were found – 120.61 Hz (111.80-136.84) on the right side and 117.10 Hz (104.75-171.69) ($p=0.861$ and $p=0.917$) on the left side. Comparing the standing on an office anti-fatigue mat to leaning against a standing support chair, no statistically significant differences were found (*dx.* $p=0.345$; *sin.* $p=0.861$).

Analysing data from gluteal muscles, no statistically significant differences were found between standing on the hard floor to leaning against a standing support chair, but the tendency to be slightly decreased was observed for the standing support chair. The mean frequency of *m. gluteus medius dx. et sin.* while standing on the hard floor was 112.91 Hz (105.15-120.05) and 107.71 Hz (102.47-145.23), but while leaning against a standing support chair 111.67 Hz (106.48-134.09) and 105.95 Hz (102.99-152.96) right and left sides respectively ($p=0.382$ and $p=0.807$). On contrary, while standing on anti-fatigue mats frequency was higher than in standing on a hard floor and while leaning against a standing support chair, statistically significant differences were found as well. While standing on a harder industrial anti-fatigue mat, the mean frequency in the gluteus medius muscle was moderately higher 119.71 Hz (111.83-131.53) and 116.27 Hz (110.12-162.14) accordingly

($p=0.001$), but while standing on a soft office anti-fatigue mat muscle activity was even higher (124.17 Hz (115.66-136.47) and 118.54 Hz (116.53-164.21); $p=0.001$.)

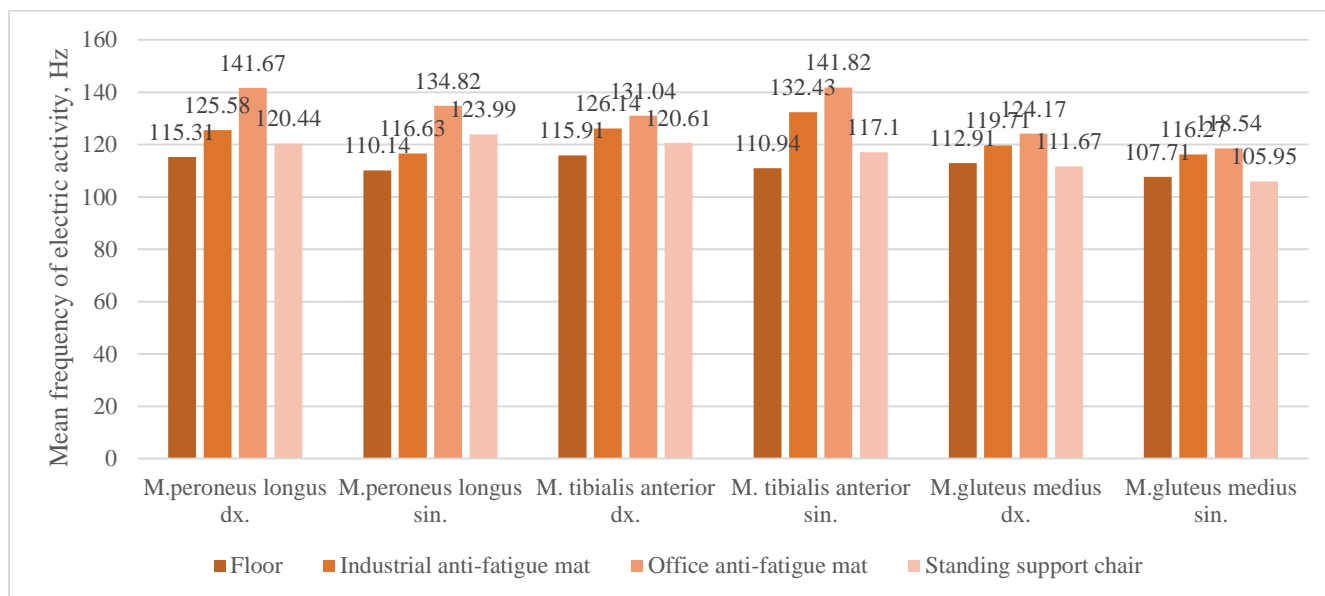


Figure 1. Mean frequency of muscle electric activity (Hz) while standing on surfaces with different softness and leaning against standing support chair

Discussion

This study has shown higher muscle electric activity in lower leg muscles while standing on softer surfaces such as an office anti-fatigue mat compared to a harder industrial anti-fatigue mat and also while leaning against a standing support chair. Higher muscle electric activity shows that there are more micromovements within the muscle. Active muscle contraction is produced by more intensive impulsations coming from the nervous system that results in higher frequency of electric potentials registered by sEMG. The higher the frequency of electric activity is registered the larger intensity of the muscle contractions happens. It was well seen in lower leg muscles while standing on softer surfaces. Scientific studies support that muscle micromovements reduce musculoskeletal discomfort of the lower limbs (Speed *et al.*, 2018) and can alleviate leg edema (Lin *et al.*, 2012).

The decrease of frequency in gluteal muscles in case of standing support chair can be explained with lower load for these muscles caused by switching the centre of gravity backwards and supporting the body with a standing support chair. This can be beneficial for alleviation of standing discomfort. Following obtained data and literature findings, it is recommended to use anti-fatigue mats and standing support chairs to reduce discomfort while standing for long periods of time and to reduce the risk of musculoskeletal disease development. However, it is important to mention that there is little data on anti-fatigue mats and standing support chairs and their long term effects since these are relatively new interventions. Most research focuses on the effects of prolonged standing and sitting in the work environment.

The limitation of the current study is the low number of volunteers that might influence the statistical significance of the findings. By increasing the study population more reliable data can be achieved. Participants of different ages, for example, ages 18 up to 65 years, should be included as well. Additionally, including sEMG of back and abdominal muscles to study design might provide more comprehensive insight in health effects of standing support adjustments, but risk of artefacts due to cardiac activity should be considered.

Conclusions

The study has shown that gluteal and leg muscle electric activity is higher when standing on softer surfaces. Increased muscle activity was most prominent in lower leg muscles, especially while standing on a softer office anti-fatigue mat. Gluteal muscle activity had a tendency to be slightly lower when leaning against a standing support chair than standing on the hard floor, but it was significantly lower than in case of anti-fatigue mats. The purpose of a standing support chair is to reduce muscle fatigue in lower extremities, but results show no statistically significant changes in the tested *m. tibialis anterior* and *m. peroneus longus*. This might be due to the soft standing surface of the standing support chair. Considering the tendency to slight decrease of electric activity in gluteal muscles while using a standing support chair, the effect on back and abdominal muscles should be evaluated in future studies.

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RADIOLOGICAL FINDINGS AND HISTOPATHOLOGY OF PAEDIATRIC CNS LESIONS – A SIX-YEAR SINGLE CENTRE STUDY OF MORPHOLOGY, COMPLICATION AND INCIDENTAL FINDING RATES

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Abstract

Radiological findings and histopathology of paediatric CNS lesions – a six-year single centre study of morphology, complication and incidental finding rates

Key Words: MRI, CNS, paediatric brain lesions, histopathology, complications, incidental findings

Introduction: Brain tumours are prevalent solid neoplasms in children, causing significant mortality rates. The diagnosis of lesions heavily relies on MRI, which is also essential for effective treatment planning and disease monitoring.

Aim: The aim of this study was to summarise localisation and morphological spectrum of paediatric brain lesions, analyse complications and incidental findings of brain MRI and CT in paediatric patients before performing brain biopsy, and to lay the foundations for future research in the field.

Materials and Methods: Medical records from the Children's Clinical University Hospital, Latvia (2016-2021) were collected. Biopsy results were accessed using laboratory system "Dialab" and radiological reports using clinical system "Andromeda". Microsoft Excel 2016 was used for data registry and IBM SPSS Statistics 28.0.1 for statistical analysis.

Results: 134 histological and 122 radiological reports were collected. 93 CNS tumours were identified of which WHO Grade I represented 53.8%. The most common histological entity was pilocytic astrocytoma. Complications or incidental findings were registered in 75 cases. The main complication was hydrocephalus and incidental finding – venous angioma. Grade IV tumours were more prone to have complications or incidental findings than Grade I ($\chi^2(1;n=66)=12,248$, $p<0.001$ and $\Phi=0.431$). Complications were less often in supratentorial tumours than in other localisations ($\chi^2(1;n=84)=15,965$, $p<0.001$ and $V=0.436$).

Conclusion: Pilocytic astrocytoma was the most common histological finding. The main complication was hydrocephaly and incidental finding – venous angioma. Brain tumour grade, as well as infratentorial and parasellar localisation has strong positive associations with complication and incidental finding rates.

Kopsavilkums

CNS bojājumu radioloģiskā un histopatoloģiskā atrade bērniem – sešu gadu viena centra pētījums par morfoloģiju, radioloģiski redzamām komplikācijām un nejaušām atradēm

Atslēgvārdi: MRT, CNS, smadzeņu bojājumi bērniem, histopatoloģija, komplikācijas, nejaušas atrades

Ievads: Smadzeņu audzēji ir izplatīti solīdi jaunveidojumi bērnu populācijā, kas ievērojami paaugstina mirstības rādītājus. Bojājumu diagnostika galvenokārt ir atkarīga no MRT izmeklējumiem, kas ir būtiski efektīvas ārstēšanas plānošanai un slimības uzraudzībai.

Mērķis: Pētījuma mērķis bija apkopot datus par bērnu smadzeņu bojājumu lokalizāciju un morfoloģisko spektru, analizēt MRT un DT datus par komplikācijām un nejaušām atradēm, kā arī izveidot pamata datu bāzi turpmākiem pētījumiem šajā nozarē.

Materiāli un metodes: Tika apkopota Bērnu klīniskās universitātes slimnīcas pacientu medicīniskā dokumentācija (2016-2021). Biopsijas rezultāti tika ievākti, izmantojot laboratorijas sistēmu "Dialab", radioloģiskie – no klīniskās sistēmas "Andromeda". Datu reģistrēšanai tika izmantota programma Microsoft Excel 2016 un statistiskai analīzei – IBM SPSS Statistics 28.0.1.

Rezultāti: Tika iegūti 134 histoloģiskie un 122 radioloģiskie izmeklējumi. Tika identificēti 93 CNS audzēji, no tiem pēc PVO klasifikācijas *Grade I* bija vērojams 53.8% gadījumu. Biežākais histoloģiskais variants bija pilocītiska astrocitoma. 75 gadījumos bija redzamas komplikācijas vai nejaušas atrades. Biežākā komplikācija bija hidrocefālija un nejaušā atrade – venoza angioma. *Grade IV* audzējiem biežāk attīstījās komplikācijas vai bija nejaušas atradnes nekā *Grade I* ($\chi^2(1;n=66)=12,248$, $p<0.001$ un $\Phi=0.431$). Komplikācijas retāk kā citās lokalizācijās attīstījās supratentoriāli ($\chi^2(1;n=84)=15,965$, $p<0.001$ un $V=0.436$).

Secinājums: Pilocītiska astrocitoma bija biežākais audzēju histoloģiskais tips. Galvenā komplikācija bija hidrocefālija un nejaušā atrade – venoza angioma. Smadzeņu audzēju malignitātes pakāpei, kā arī infratentoriālai un parasellārai lokalizācijai ir cieša pozitīva asociācija ar komplikācijām un nejaušām atradēm.

Introduction

Disorders affecting the central nervous system (CNS) in the paediatric population pose significant challenges and often necessitate surgical intervention. These disorders encompass a wide range of non-tumorous abnormalities in the brain and spinal cord, including cerebral structural developmental anomalies, vascular malformations, and others, alongside benign and malignant tumours. The symptoms associated with these disorders can vary greatly, ranging from asymptomatic to severe progression, and in some cases, may even result in fatality. Among these conditions, brain tumours emerge as the most prevalent solid tumours in children and represent a leading cause of increased mortality rates. Furthermore, they rank as the second most common paediatric tumours after haematological malignancies (Fahmideh 2021). The survival of patients with brain tumours is influenced by various factors, such as the histological type of the tumour, its location, the patient's age at the time of diagnosis, the presence of complications, and the patient's ethnicity. However, advancements in diagnostic and therapeutic approaches over time have contributed to improved survival rates (Fahmideh 2021). Brain tumours also exert a significant negative impact on public health, owing to high mortality rates, treatment expenses, and the consequent public perception surrounding the disease, particularly concerning children who may experience disability or premature death (Martīņuka 2015).

Unlike neoplasms in other localisations, that are staged using TNM classifications, primary brain tumours are categorised according to the World Health Organisation (WHO) Classification of CNS tumours, which relies not only on histology, but also on molecular data to define tumour entities (Louis 2016). According to this classification, glial tumours, including low-grade gliomas and high-grade gliomas, are the most common brain tumours, followed by embryonal tumours (Resende 2021). The most common type of paediatric brain tumours is pilocytic astrocytoma (Ostrom 2017). The separation of certain tumour entities may have a significant impact on appropriate treatment and could potentially change outcomes (Resende 2021).

Another aspect of qualitative diagnosis is medical imaging. The detection and diagnosis of intracranial tumours and other lesions heavily rely on magnetic resonance imaging, because it has better soft tissue resolution and less radiation than computer tomography, and it is also essential for effective treatment planning and disease monitoring (Jaju 2022). In addition, recent improvements in the field of radiomics enable better detection of molecular and histological features of various brain tumours, especially high-grade gliomas, from radiological images (Vagvala 2022). The methods utilized in radiomics require gathering and usage of semantic data, such as lesion location, assessment for possible complications, incidental findings or other lesion specific features, that are later correlated with morphological and molecular type or tumour grade. It has potential to facilitate better

clinical decision making and assist medical professionals, especially in the field of oncology (Gillies 2015).

Speaking about data from Latvia, CNS tumours were the most common paediatric malignancies (25,1%) with the highest mortality rates (30,4%) in Latvia from year 2000 to 2013 (Martīņuka 2015). In addition, unified cancer registry is still not fully operable and available for research in Latvia which can make it difficult to obtain data and analyse problems directly in our country. It is important, because improved tumour categorisation and molecularly directed therapies have shown efficacy in brain tumour treatment and could improve life expectancy of those patients (Pollack 2019).

Aim of this study was to summarise and analyse localisation and morphological spectrum of paediatric brain lesions in the Children's Clinical University Hospital, Latvia (2016-2021), to summarise and analyse complications and incidental findings of brain MRI and CT in paediatric patients before performing brain biopsy, and to lay the foundations for future research in the field.

Material and Methods

The research was approved by Riga Stradiņš University Ethics Committee and the study was conducted in accordance with the Declaration of Helsinki.

In this retrospective study medical records of 134 patients admitted and treated in the Children's Clinical University Hospital in Latvia, during the period between 01.01.2016 and 31.12.2021 were collected for data analysis. Age range for all patients were from 0 to 19 full years. Histological reports of surgically treated CNS formations were gathered from the laboratory system "DiaLab". Inclusion criteria - newly diagnosed CNS lesion, confirmed histological type, WHO grade for CNS tumours. We excluded repeated surgical interventions. In some cases, the histological material was sent to London, UCL Institute of Neurology for confirmation and revised histological reports were used in the results.

Additional information for every collected case, mainly on brain imaging, complications, incidental findings, and revised histological reports were accessed using a clinical system "Andromeda". Criteria for radiological reports - imaging should be performed before brain biopsy to exclude iatrogenic complications. Criteria for localisation grouping of brain lesions - supratentorial localisation should include region of the brain located above the tentorium cerebelli; infratentorial region – below the tentorium cerebelli; parasellar region – encompasses the cavernous sinuses, suprasellar cistern, hypothalamus, and ventral inferior third ventricle (Simão 2018); meninges should be included in any group according to localisation.

The 2016 World Health Organisation's Classification of the CNS tumours was used for morphological grouping of CNS tumours. Non-tumorous lesions were grouped according to the 11th Revision of the International Classification of Diseases (ICD-11). Microsoft Excel 2016 programme

was used for data registry. Statistical analysis was performed using IBM SPSS Statistics 28.0.1 programme with a significance: $p < 0,05$.

Results

In total 134 histological reports were collected, 73 (54,5%) of them male patients and 61 (45,5%) female patients respectively. Age range for them were from 0 to 19 full years. Age had a bimodal distribution with two peaks around 5 and 14 years. The average age was 9 years (mean=8,87; median=9,00). Age distribution is shown in Figure 1.

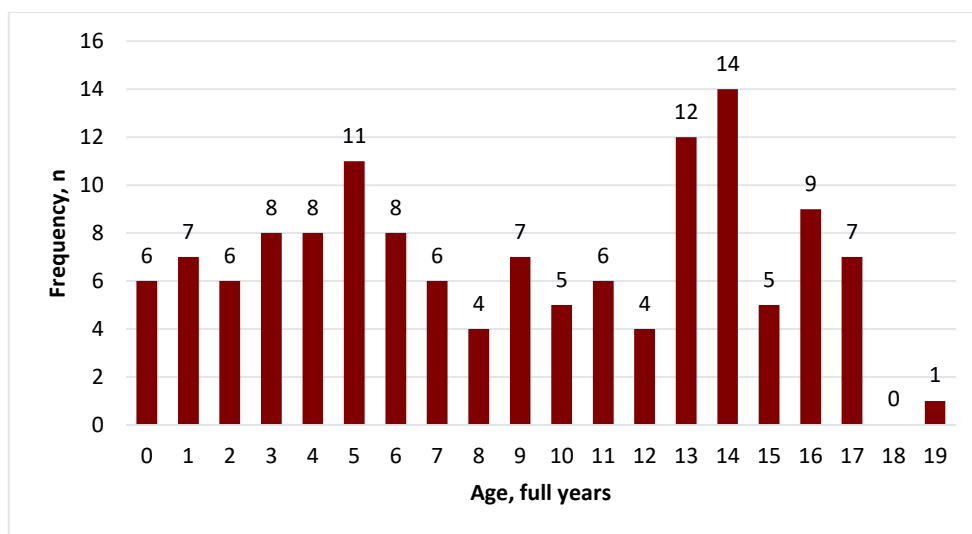


Figure 1. Age distribution

124 (92,5%) of CNS lesions were located in the brain and only 10 (7,5%) in the spinal cord. From all 124 brain lesions 70 (56,5%) located in supratentorial, 44 (35,5%) in infratentorial and 10 (8,0%) in parasellar region. Localisation of all CNS lesions, including spinal cord, is shown in Figure 2.

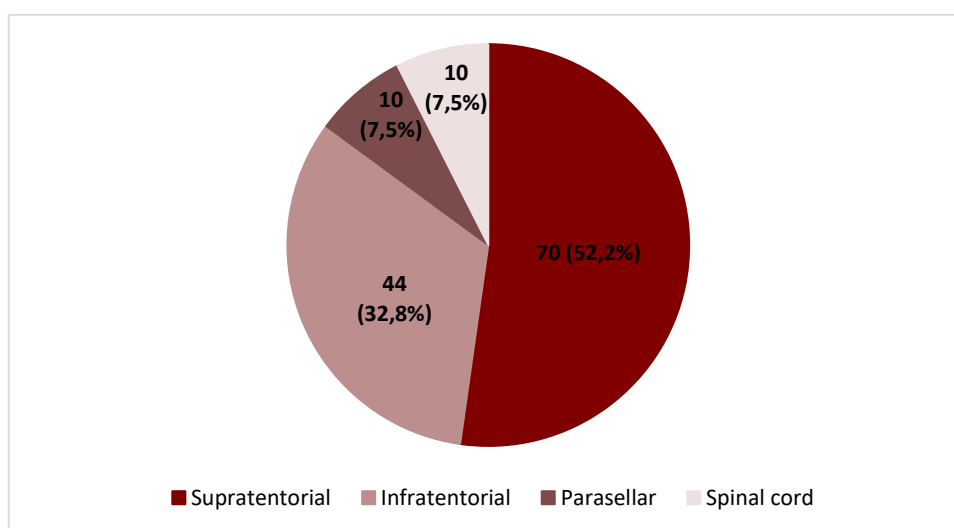


Figure 2. Localisation of CNS lesions

93 tumours with assigned WHO CNS tumour grade were identified, of which 37 (39,8%) located in supratentorial, 41 (44,1%) in infratentorial, 8 (8,6%) in parasellar region and 7 (7,5%) were found in the spinal cord (Figure 3).

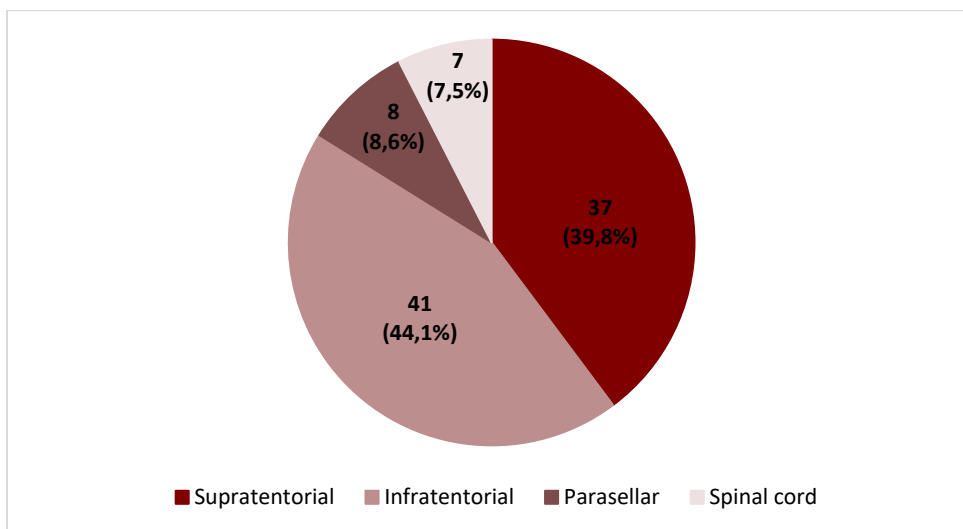


Figure 3. Localisation of CNS tumours

From all 93 CNS tumours 50 (53,8%) represented with WHO Grade I, 16 (17,2%) with Grade II, 3 (3,2%) with Grade III and 24 (25,8%) with Grade IV. Grade distribution in CNS tumours is summarised in Figure 4.

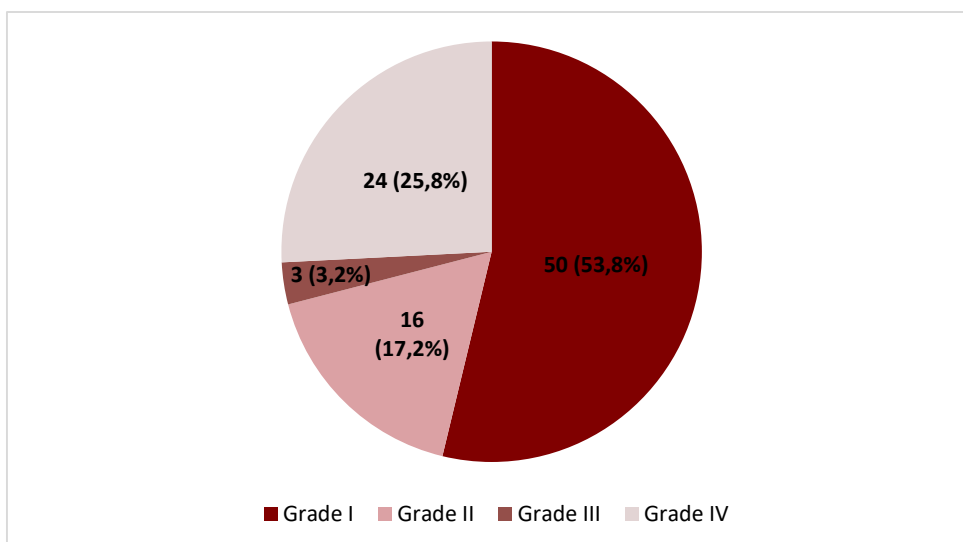


Figure 4. WHO grade of CNS tumours

In total 95 histological reports of CNS tumours were registered, 2 of them were missing WHO grade, therefore are not mentioned below, and will be described in the discussion. The most common

histological tumour group according to the WHO CNS tumour classification was other astrocytic tumours (n=34; 36,6%), that included pilocytic astrocytomas, pleomorphic xanthoastrocytomas and subependymal giant cell astrocytoma. Other groups, that were identified in our study, were diffuse astrocytic and oligodendroglial tumours (n=15; 16,1%) with diffuse astrocytomas, glioblastomas and diffuse midline gliomas; embryonal tumours (n=17; 18,3%) with medulloblastomas, CNS embryonal tumours and atypical teratoid/rhabdoid tumour; neuronal and mixed neuronal-glial tumours (n=10; 10,8%) with gangliogliomas, atypical central neurocytomas and dysembryoplastic neuroepithelial tumours; ependymal tumours (n=5; 5,4%) with ependymomas and myxopapillary ependymomas; tumours of the cranial and paraspinal nerves (n=3; 3,2%) with schwannomas; tumours of the sellar region (n=3; 3,2%) with adamantinomatous craniopharyngiomas; meningiomas (n=3; 3,2%) with atypical meningioma, fibrous meningioma and meningothelial meningioma; choroid plexus tumours (n=2; 2,2%) with atypical choroid plexus papilloma and choroid plexus carcinoma; tumours of the pineal region (n=1; 1,1%) with pineoblastoma.

The most common histological tumour type was pilocytic astrocytoma (n=30; 22,4%), followed by medulloblastoma (n=14; 10,4%) and diffuse astrocytoma (n=7; 5,2%). All histological types of CNS tumours are summarised in Figure 5.

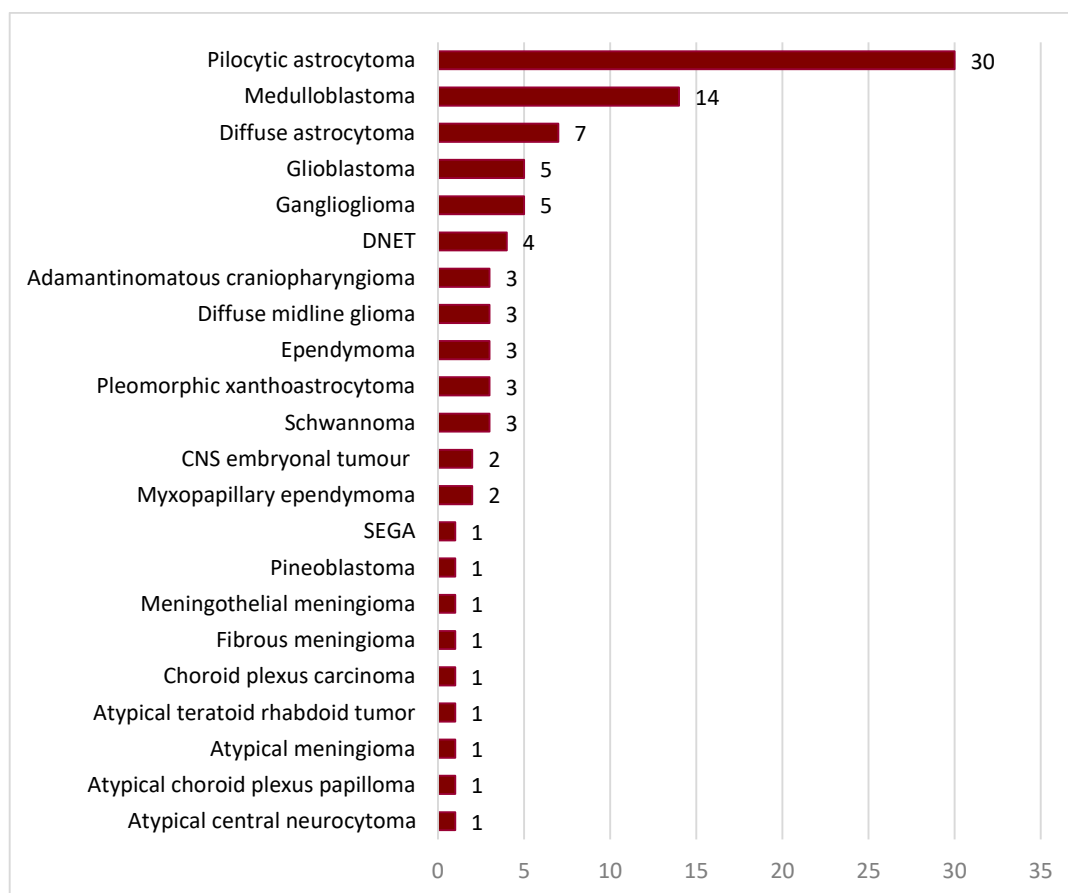


Figure 5. Histological types of CNS tumours

In total 37 histological reports of CNS non-tumorous lesions were registered; 2 cases of CNS lesions had an insufficient material size. The most common histological group was cerebral structural developmental anomalies (n=18; 48,6%) The most common histological non-tumorous lesion type was focal cortical dysplasia type IIb (n=9; 24,3%), followed by vascular malformation (n=8; 21,6%) and focal cortical dysplasia type IIa (n=4; 10,8%). Other histological types of CNS non-tumorous lesions are visible in Figure 6.

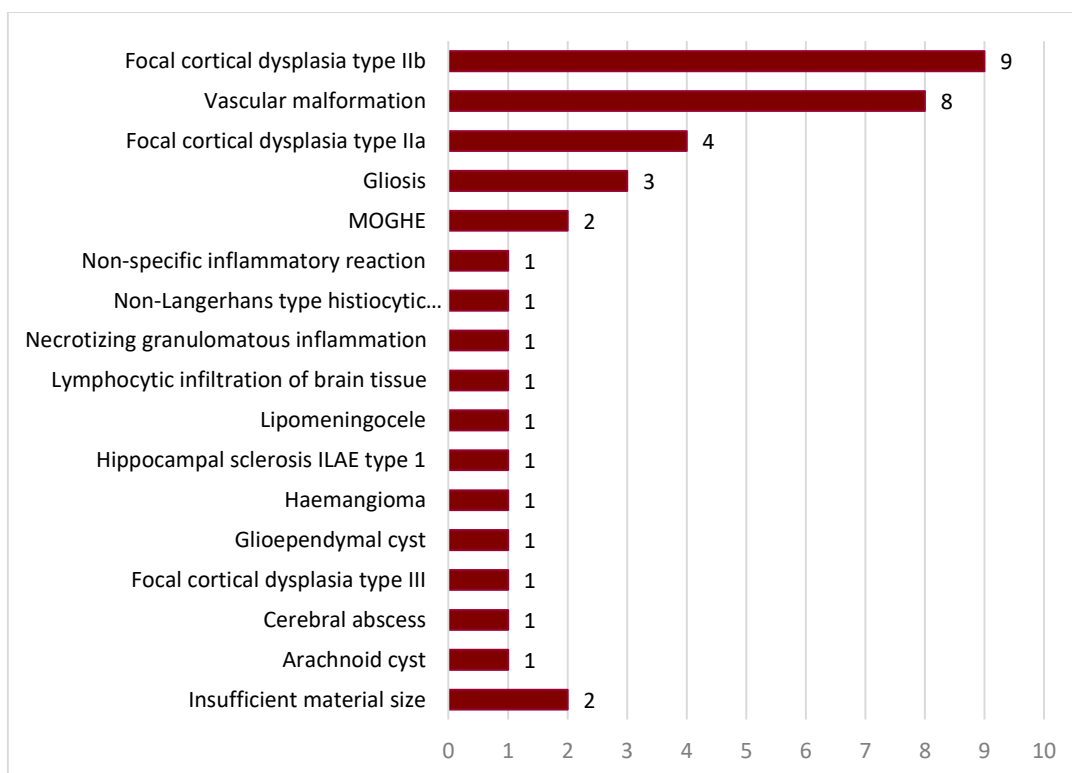
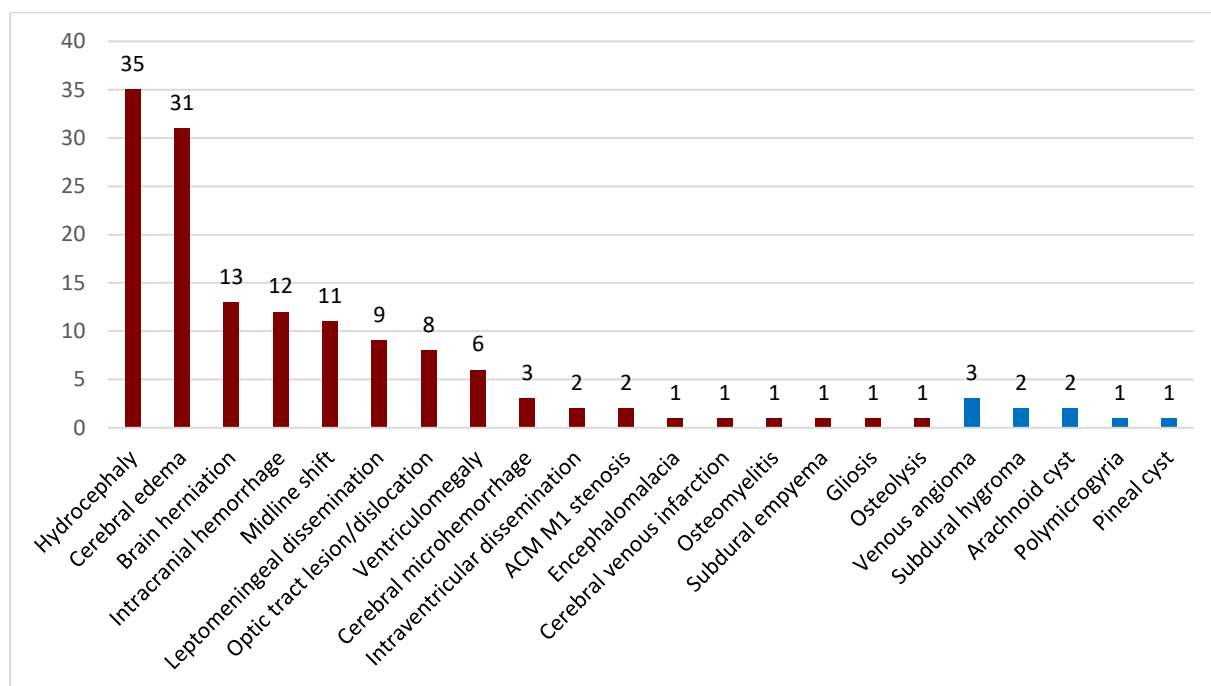


Figure 6. **Histological types of CNS non-tumorous lesions**

In total 118 brain MRI and 4 CT reports were collected. In 12 cases radiological findings were missing. Complications or incidental findings were registered in 75 (61,5%) cases. The complications were mainly seen in patients with an underlying brain tumour (58 (77,3%) cases of 75) and one patient often featured multiple complications at the same time. The main complications were hydrocephaly (n=35; 28,7%), cerebral oedema (n=31; 25,4%) and brain herniation (n=13; 10,7%). Optic tract was affected in 8 (6,6%) cases. The incidental findings were found less common than complications. The main incidental findings were venous angioma (n=3; 2,5%), subdural hygroma (n=2; 1,6%) and arachnoid cyst (n=2; 1,6%). All complications and incidental findings are summarised in Figure 7.



- Complications
- Incidental findings

Figure 7. **Complications and incidental findings in CNS lesions**

We also found some associations in data. Grade IV tumours were more prone to have complications or incidental findings than Grade I ($\chi^2(1; n=66)=12,248; p<0,001$ and $\Phi=0,431$). Complications occurred more often in infratentorial and parasellar tumours than in supratentorial localisation ($\chi^2(1; n=84)=15,965; p<0,001$ and Cramer's $V=0,436$).

Discussion

It is crucial to highlight that this study solely focuses on examining the morphology, localisations, complications, and frequencies of paediatric brain lesions that underwent histopathologic examination within Latvia. However, it should not be regarded as a comprehensive cancer registry due to certain limitations. Firstly, it is important to note that this study does not encompass all cases, as some patients and their families opted for treatment abroad following radiological diagnosis without undergoing biopsy. Secondly, as the data were retrospectively collected and comprehensive information regarding symptoms and disease progression was not available for every patient, it was challenging to discern whether the radiologically identified complications were directly associated with the primary disease or incidental findings.

Two cases were excluded from our tumour statistics due to lack of WHO grading. Those were CNS germinoma that belongs to germ cell tumour's group, because it is hard to set a grade for this tumour (Ilcus 2021). In our case, grading was not available. Another tumour was

ganglioneuroblastoma, because it is a peripheral nervous system tumour, but it was located right next to the spinal cord.

An additional challenge arose from the inability to precisely classify certain central nervous system lesions based on their specific localizations. This difficulty primarily stemmed from instances where these lesions affected multiple regions of the brain simultaneously, making it difficult to determine the exact origin of the tumour. Consequently, in certain cases, the lesions affecting diencephalon, for instance, were categorized as a supratentorial lesion, while in others, were classified as an infratentorial lesion. To address this issue, we included the lesion in the group corresponding to the location where the largest portion of it was situated.

As widely recognized, primary central nervous system tumours are more prevalent among the paediatric population compared to adults, with genetic predisposition being the primary risk factor. Regrettably, at present, no definitive solution exists to halt tumour development in the first place, and treatment primarily focuses on impeding progression and surgical resection of pathogenic tissue. However, there are also modifiable factors, such as ionizing radiation, that can be prevented (Fahmideh 2021). It is important to note that no patient data was specifically collected to assess potential risk factors for tumour progression.

There is a possibility that younger patients included in the study harboured more aggressive pathogenic gene variants compared to their older counterparts, potentially resulting in an earlier diagnosis and a more severe disease course. To gain further insights and identify potential correlations between age, tumour type, molecular status, and disease progression, it would be beneficial to collect molecular data. However, it should be noted that such data was not available for every patient, particularly for older cases predating 2019. Therefore, future research should focus on including more recent cases with comprehensive molecular information pertaining to both the patient and tumour tissue samples.

Our study findings revealed that Grade IV tumours exhibited a higher incidence of complications compared to Grade I tumours, indicating a more aggressive disease course. This heightened complication rate can be attributed to the limited capacity of the skull to accommodate evolving pathological processes due to a lack of available space. Notably, complications were more frequently observed in the infratentorial and parasellar regions, as these areas are anatomically constrained in terms of space. Even the presence of a small volumetric lesion in these locations can lead to a more rapid impact on the brain. Having this knowledge enables healthcare professionals to be vigilant, anticipate potential complications and outcomes, and implement preventive measures proactively. Additionally, it can be utilized in radiomics to develop models, that can improve diagnostic, prognostic, and predictive accuracy in the future.

Conclusions

The results are compatible with the latest literature data – the most common CNS tumours were glial tumours, followed by embryonal tumours. Pilocytic astrocytoma was the most common paediatric brain tumour histological finding, followed by classic medulloblastoma.

The most common complication of a CNS lesion was hydrocephaly, and the most common incidental finding was venous angioma.

CNS tumours were more often located in the infratentorial region, but non-tumorous lesions in the supratentorial region.

Brain tumour grade, as well as infratentorial and parasellar localisation have statistically significant strong positive associations with complication and incidental finding rates.

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SURGICAL MANAGEMENT OF HEAD AND NECK SKIN TUMOROUS LESIONS. ANALYSIS OF 86 CLINICAL CASES

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Abstract

Surgical management of head and neck skin tumorous lesions. Analysis of 86 clinical cases

Key Words: Skin tumor, skin cancer, basal cell carcinoma, wound closure, skin flap design

Introduction: One of the most common cancer types in Latvia is skin cancer. Surgery is one of the radical treatment methods for skin tumorous lesions with different approaches. The face and neck area are the most esthetically sensitive area of skin to perform surgical intervention.

Aim of the study: to investigate surgically treated skin tumorous lesions in face and neck area and analyze wound closure techniques.

Methods and materials: This is a retrospective descriptive and quantitative study. Literature review was done during the period between September 2021 and March 2023. Quantitative research was done from March 2023 until April 2023. The obtained data was used for further analysis. The primary data collection was done in Microsoft Office Excel Version 2303, and the data analysis was done in SPSS Statistics 29.0.0.0.

Results: There were used five wound closure techniques. When analyzing multiple group variables with nonparametric Mann-Whitney U test, significant differences in wound closure technique with microvascular flap and skin lesion size with the tumor ($p < 0.001$) was found.

Conclusion: There are statistically significant subsequent differences in the wound closure technique using microvascular flap and skin lesion size with the tumor. The local flap was found to be the most common wound closure technique.

Kopsavilkums

Galvas un kakla ādas audzēju ķirurģiskas ārstēšanas menedžments. 86 klīnisko gadījumu analīze

Atslēgvārdi: Ādas audzējs, ādas vēzis, bazālo šūnu karcinoma, brūču slēgšana, ādas lēvera dizains

Ievads: Viens no izplatītākajiem vēža veidiem Latvijā ir ādas vēzis. Ķirurģija ir viena no radikālām ādas audzēju bojājumu ārstēšanas metodēm, kurai ir dažādas pieejas. Galvas un kakla zona ir estētiski sensitīvs apvidus, kur veicama ķirurģiskas iejaukšanās.

Pētījuma mērķis: izpētīt ķirurģiski ārstētus ādas audzējus galvas un kakla rajonā, un analizēt brūču slēgšanas tehnikas.

Materiāli un metodes: Šis ir retrospektīvs aprakstošs pētījums. Literatūras apskats tika veikts laika posmā no 2021. gada septembra līdz 2023. gada martam. Kvantitatīvā datu izpēte veikta no 2023. gada martam līdz 2023. gada aprīlim. Iegūtie dati tika izmantoti turpmākai analīzei. Primārā datu vākšana tika veikta programmā Microsoft Office Excel Version 2303, un datu analīze tika veikta programmā SPSS Statistics 29.0.0.0.

Rezultāti: Tika izmantotas 5 brūču slēgšanas. Izmantojot neparametrisku Mann Whitney U testu tika atrastas statistiski nozīmīgas atšķirības brūču slēgšanas tehnikā ar mikrovaskuāru lēveri un ādas preperāta izmērā ar tumoru ($p < 0.001$).

Noslēgums: Tika pierādīts, ka ir statistiski ticamas atšķirības brūču slēgšanas tehnikā ar mikrovaskuāru lēveri un ādas preperāta izmērā ar tumoru un lokāla audu plastika ir biežāk pielietotā brūču slēgšanas tehnika.

Introduction

Skin tumor is abnormal growth of skin cells. Tumors can be benign or malignant. Malignant skin tumor is defined as skin cancer. Generally, skin cancer is classified as nonmelanoma skin cancer (NMSC) or melanoma (Gruber et al. 2023). Histology image remains the gold standard to differentiate benign and malignant tumor (Xie et al., 2020). Cancer is a major public health problem worldwide (Siegel et al., 2020).

Skin cancer is the most dangerous kind of skin disease and a public health problem in the world. One out of every three patients diagnosed with cancer every year in the world is skin cancer (Evgin, 2023). The most common types of skin cancer (basal cell carcinoma, squamous cell carcinoma and melanoma) are becoming increasingly common (Bishop et al., 2014). Surgery is one of the treatment

options for skin cancer. Wide local excisions of basal cell carcinoma, squamous cell carcinoma and melanoma, represent a prominent part of Oral and Maxillofacial surgery (Elpida et al., 2021). After the surgical excision there might be sizeable defects. Closing the wound requires managing skin physical properties and do advancement flaps, free skin graft or even microvascular reconstruction. Repair may prove especially challenging when the surgeon is faced with a large defect in facial area (Vesely et al., 2021). The clinicians care for wounds ranging from minor and simple lacerations or abrasions to complex wounds. Wound closure techniques have evolved significantly and now range from simple sutures to adhesive compounds, and techniques have also improved. Multiple techniques can be used for wound closure. These include sutures, staples, and adhesives (Azmat,2023).

Early melanoma and nonmelanoma skin cancer of the facial area are primarily treated with surgery. There is little known about patient outcomes of the facial skin cancer population. Treatment effectiveness has traditionally focused on morbidity and mortality, however the patient's perspective is increasingly considered integral. Patients that undergo surgical treatment for skin cancer are left with varying degrees of scarring (Lee et al., 2015).

Wound closure requires deep understanding of wound physiology, anatomy, and the healing phase of the wound. The basic principles of wound closure, diabetes control, normal nutrition status, infection control, mechanical stress avoidance, and nursing care are all important elements in achieving healing of acute and chronic wounds. This goal is achievable only through the interdisciplinary approach to wound healing (Simman,2009). Aim?

1. Materials and methods

This is a retrospective descriptive and quantitative study.

The aim of the study was to investigate skin tumorous lesion surgical management and to analyze the wound closure techniques.

Hypothesis to be tested:

First: Is there significant meaning between the wound closure technique with microvascular flap and skin lesion size with the tumor.

Second: the most common wound closure technique is with local flap.

The literature review was done during the period between September 2021 and March 2023. English literature was screened for skin tumorous lesion surgical management and wound closing techniques, skin cancer types, classification, epidemiology, and pathogenesis. Quantitative research was done from March 2023 until May 2023.

Inclusion criteria's

1. Age ≥ 18 years

2. Patients who have been diagnosed with primary facial skin tumorous lesion in one localization and have underwent surgical treatment in Riga East University Hospital “Oncology center of Latvia” 3A Head and neck in the surgery department from December 2021 till June 2022.

3. Patients who correspond full protocol data.

Exclusion criteria's

1. Age \leq 18 years.
2. Cancer recurrence.
3. Multiple skin tumor localizations.

In total 86 patients were included and correspond to inclusion criteria.

Results

In total 86 patients with skin tumorous lesions in head and neck area were analyzed in this study. All patients were surgically treated in Riga East University Hospital, Oncology Centre of Latvia 3A head and neck surgery department. All patients were included according to inclusion criteria. Distribution of gender were male 41.9% (n=39) and 58.1% (n=54) female. The predominant sex was female (Figure 3.1).

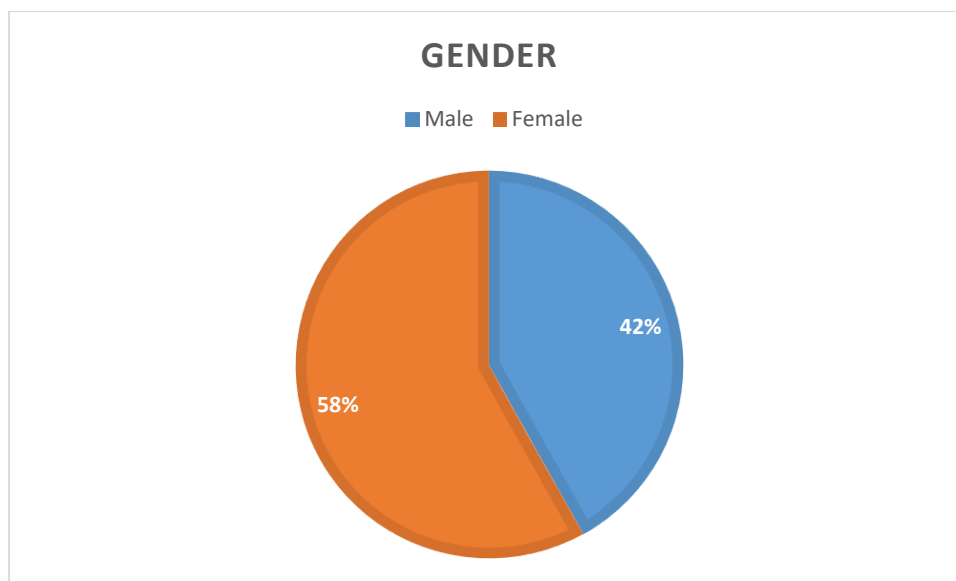


Figure 3.1. Pie chart of gender distribution

The age group for study population ranged from 20 to 87 years, from where average age was 63.9 years (Tab. 3.1).

Table 3.1. Frequency of age, skin pathological sample largest size with the tumor in cm, time of surgery

		Age	Skin pathohistological sample largest size with the tumor, cm	Time, min
N	Valid	86	86	86
	Missing	0	0	0
Mean		63.90	3.020	64.07
Median		65.50	2.700	40.00
Mode		78	3.0	20
Std. Deviation		14.985	2.5359	76.921
Minimum		20	.3	15
Maximum		87	21.0	450
Percentiles	25	55.00	1.500	25.00
	50	65.50	2.700	40.00
	75	76.25	3.625	65.00

The age of the 86 patients was not normally distributed according to the histogram and by observing frequencies of the mean, median and mode (Figure 3.2.). According to frequency median age was 65.50 years, minimum was 20 years and maximum age was 87 years. Standard deviation was 15. The interquartile range is from 55 years till 76.25 years.

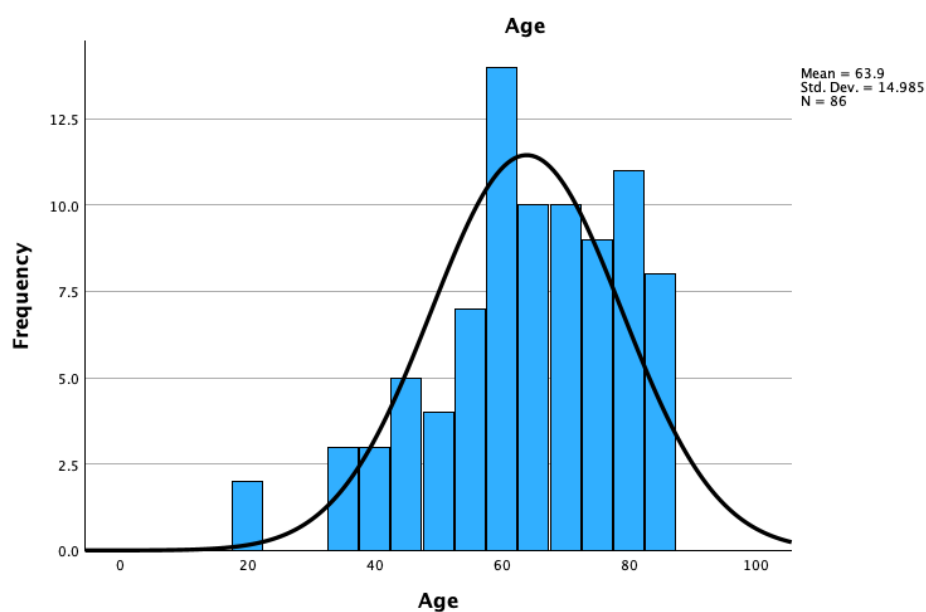


Figure 3.2. Histogram of age

After pathohistological examination 77.9% (n=67) tumorous lesions were malignant and 22.1% (n=19) was benign (Figure 3.2).

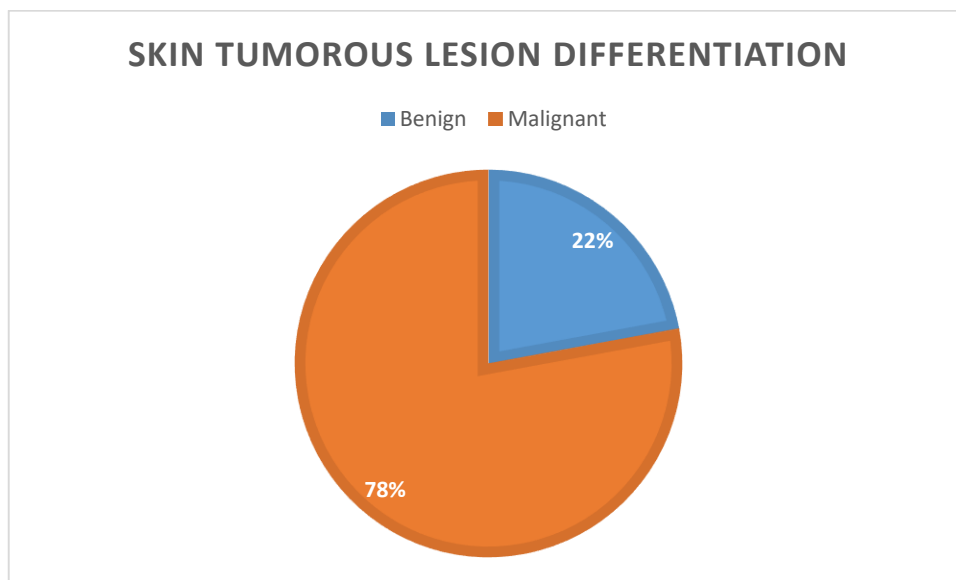


Figure 3.2. **Pie chart of skin tumorous lesion pathohistological differentiation**

The skin lesion size with the tumor was measured in centimeters according to description in pathohistological results. The minimum size of skin with the lesion was 0.3 centimeters and maximum 21 centimeters. Mean skin lesion with tumor size was 3.020 centimeters and standard deviation 2.4811 (Table 3.1.).

The minimum time in minutes which was needed to perform surgery was 15 minutes and maximum time 450 minutes (Table 3.1.). Mean time when surgery is performed is 64.07 minutes, standard deviation 76.921.

According to the documentation of performed surgery, there were used five wound closure techniques: Local flap 57% (n=49) cases, primary closure 19% (n=16) cases, rotated flap 14% (n=12) cases, free skin graft 2% (n=2) cases and microvascular flap 8% (n=7) cases (Figure 3.3.). Local flap was the most used wound closure technique in 57% of the cases.

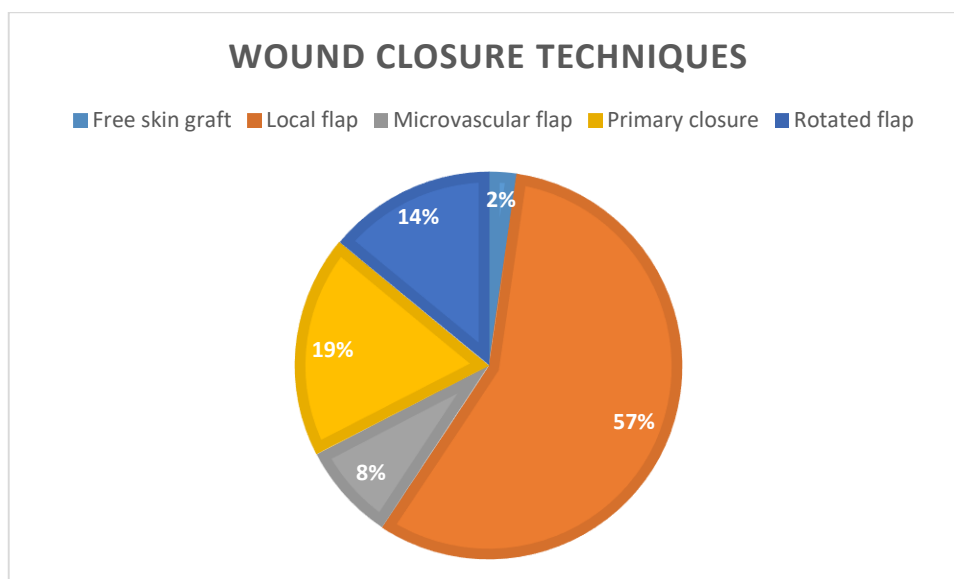


Figure 3.3. Wound closure techniques

When analyzing multiple group variables with nonparametric Mann-Whitney U test, significant differences in wound closure technique with microvascular flap and skin lesion size with the tumor ($p < 0.001$) was found. There were no statistically significant differences in wound closure techniques with free skin graft ($p = 0.656$), local flap ($p = 0.133$), primary closure ($p = 0.747$), rotated flap ($p = 0.504$) and skin lesion size with the tumor.

Discussion

Following tumor excision, facial reconstruction is often challenging, yet many techniques are available for restoring native anatomy and achieving optimal aesthetic outcomes. In general, reconstructive strategies should be patient-centered and tailored to the defect size, depth, location, and involved structures. Finally, patient expectations should be realistically set to leave both the patient and surgeon satisfied with the aesthetic results (Badash et al., 2019). Local flaps give the best results and are the first choice for reconstruction of the face (Rao et al., 2016).

Conclusions

Both hypotheses were approved. There are statistically significant subsequent differences in the wound closure technique using microvascular flap and skin lesion size with the tumor. The local flap was found to be the most common wound closure technique.

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MATEMĀTIKA UN FIZIKA / MATHEMATICS AND PHYSICS

THE IMPORTANCE OF LANGUAGE SKILLS IN THE MATHEMATICS LEARNING PROCESS

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Abstract

The importance of language skills in the mathematics learning process

Key Words: *mathematical language skills, proposition, truth value, counterexample*

One of the innovations in the new Skola-2030 mathematics curriculum is the actualization of language skills. The study aims to identify the types of tasks that involve the use of examples or counter-examples and are designed to enhance language skills in the mathematics learning process. In 2022, a survey of students from the Daugavpils University program "Primary Education Teacher" was conducted (N=25). This pilot research shows that future mathematics teachers have difficulties in formulating mathematical propositions. To improve language skills, the authors recommend using the following four types of tasks related to the use of examples or counterexamples: tasks that require explanation; tasks involving reasoning from specific instances to general principles; tasks using counterexamples to assess the truth value of propositions; and tasks that involve the application of visual, kinesthetic, and audial models. The proposed types of tasks give the opportunity for teachers and pupils to improve their questioning skills, the ability to substantiate propositions and to use models.

Kopsavilkums

Valoddarbības prasmju aktualitāte matemātikas mācību procesā

Atslēgvārdi: *valoddarbības prasmes, izteikums, patiesumvērtība, pretpiemērs*

Pilnveidotajā matemātikas mācību jomas standartā viens no jauninājumiem ir valoddarbības prasmes aktualizācija. Pētījuma mērķis ir noteikt uzdevumu veidus, kuri saistīti ar piemēru vai pretpiemēru izmantošanu un paredzēti valoddarbības prasmes uzlabošanai matemātikas mācību procesā. 2022. gadā tika veikta Daugavpils Universitātes skolotāju programmā "Sākumizglītības skolotājs" studējošo aptauja (N=25). Pilotpētījums parādīja, ka topošajiem matemātikas skolotājiem sagādā grūtības formulēt izteikumus ar matemātisku saturu. Lai uzlabotu valoddarbības prasmes, autori iesaka izmantot četrus uzdevumu veidus, kuri saistīti ar piemēru vai pretpiemēru izmantošanu: uzdevumi ar prasību izskaidrot; spriešana no konkrētā uz vispārīgo; uzdevumi ar stratēģiju-pretpiemēra lietošana apgalvojuma patiesumvērtības noteikšanai; vizuālu, kinestētisku un audiālu modeļu pielietošanas uzdevumi. Piedāvātie uzdevumu veidi skolotājiem un skolēniem dod iespēju mācīties uzdot mērķtiecīgus, daudzveidīgus jautājumus, pamatot vai atspēkot apgalvojumus, modelēt.

Introduction

A competency-based curriculum for primary and secondary education was established by the regulations of the Cabinet of Ministers of the Republic of Latvia (CM) in 2018 and 2019 (MK 747 2018; MK416 2019). The impetus for this research stemmed from an examination of these mathematics curricula, where a focus on language skills is evident. The authors explore why it is necessary to update language skills in the mathematics learning process. Which language skills are emphasized in the mathematics curriculum? How adept are students in teacher programs at formulating mathematical propositions and determining the truth value of these propositions, using examples and counterexamples? For which types of tasks is the ability to construct examples and counterexamples valid?

The study aims to identify the types of tasks that involve the use of examples or counter-examples and are designed to enhance language skills in the mathematics learning process. It reveals

the need for improved language skills, as evidenced by the poor performance of Latvian pupils in the 2013 Program for International Student Assessment (PISA) test and the state exam (SE) in understanding mathematical concepts and models (OECD 2013, skola2030 2019). Similarly, there is a determination to keep pace with global changes in the field of education (skola2030 2019). Language skills are particularly emphasized in the first two Big Ideas of the new Skola-2030 mathematics curriculum (MK747 2018; MK416 2019). Firstly, the focus is on understanding mathematical terms, concepts, special symbols, relationships, and graphic organizers (tables, graphs, diagrams, schemes, maps). Secondly, the emphasis is on using these elements meaningfully, which includes formulating properties and features, reasoning, justifying, and proving. Thirdly, the curriculum aims at developing communicative skills.

In December 2022, a survey was conducted among students in teacher programs at Daugavpils University (DU) with a sample size of 25 (N=25). The survey found that future mathematics teachers possess adequate skills in establishing the truth value of propositions. However, they face challenges in formulating mathematical propositions suitable for 1st to 6th-grade pupils. Consequently, it is crucial to explore techniques that would enhance the language skills of both teachers and pupils. To effectively implement the improved curriculum in mathematics, a diverse range of methods, techniques, models, and, importantly, tasks should be employed. To bolster language skills within the context of learning mathematics, the authors recommend the utilization of tasks that involve the use of examples or counterexamples. These tasks include the requirement to explain, reasoning from specific cases to general principles, using a counterexample to determine the truth value of a proposition, and tasks that incorporate visual, kinesthetic, and audial models.

Types of tasks for improving language skills in the mathematics learning process

The implementation of a competency-based curriculum in Latvia began in the 2020/2021 academic year, starting with grades 1, 4, 7, and 10, and is being introduced gradually (MK747 2018, MK416 2019; skola2030 2019). This curriculum places a strong emphasis on language skills to facilitate active pupil engagement in the cognitive process, aided by teachers. The shift in focus aligns with efforts seen in other countries (such as Finland, Canada, Estonia, Singapore, and New Zealand) to update their teaching content approximately every ten years (skola2030 2019). In Latvia, over ten years had elapsed since the previous curriculum was introduced (MK1027 2006). Another motivating factor was that a smaller percentage of Latvian pupils attained the highest levels of mathematics proficiency in PISA tasks compared to the European average (Geske, Grīnfelds, Kangro, Kiseļova, Mihno 2013; OECD 2013). Additionally, there was a noticeable lack of understanding of mathematical concepts in SE in 2013. For instance, 46% of secondary school pupils did not grasp the concept of a 'real interval', and 48% confused the concepts of 'parallel' and 'perpendicular' (Vorobjovs 2021).

Language skills, including reading, writing, speaking, and listening, are typically developed in language subjects, enabling their effective application across other school subjects (skola2030 2019). Mathematics possesses its own unique language, necessitating a gradual transition from everyday language to mathematical language. The first and second Big Ideas of the curriculum underscore the significance of language skills in mathematics learning. These skills involve using mathematical language for communication, scientific description of concepts, ideas, and solutions, and recognizing that solving mathematical problems involves identifying structures, systems, and relationships, as well as making and proving generalizations (MK747 2018). Key language skills integral to the mathematics learning process include explaining (concepts, personal actions, and decisions), drawing conclusions from specific cases to generalize in new situations, formulating and testing generalizations, and employing strategies and models (MK747 2018; MK416 2019). The enhanced mathematics curriculum emphasizes the assessment of understanding and meaningful use of various language elements: mathematical symbols; concepts (such as area); strategies (involving the use of diverse techniques for problem-solving); and mathematical ideas (like equivalence and truth) (MK747 2018). Communication, particularly in the exchange of ideas, is also a crucial component. Pupils construct their understanding based on their perceptions and existing knowledge, learning through experience. Active participation and communication are essential, including speaking, representing, and drawing. “A pupil can only demonstrate understanding of a concept or relationship if they are able to explain it, articulate it in their own words, link it with other concepts and relationships, cite examples, and create their own” (Mencis, Kumerdanka 2021: 129). In A. Vorobjovs' study it is noted that during mathematics lessons, teenagers tend to exhibit more success with inward communication, which includes reading, perceiving, and interpreting statements and information. However, they encounter difficulties with outward communication, such as explaining, presenting, and arguing their solutions and results. The study also highlights that the verbal and written explanation of ideas contributes to improving students' understanding and underscores the need for greater emphasis on developing outward communication skills in the educational process (Vorobjovs 2021, 98).

The 'Elements of Mathematical Logic and Set Theory' (MLST) course, included in the Professional Bachelor's study program “Primary Education Teacher” at DU, is designed to cultivate the ability to explain complex information in a clear and focused manner. In this course, students learn that propositions are statements that can be definitively classified as true or false. The ability to formulate such mathematical propositions is recognized as a crucial language skill in mathematics. Examples and counterexamples are separate propositions and play a vital role in fostering an understanding of new mathematical objects and relationships (MK747 2018). It is advised to introduce these concepts early in education, such as in preschool, where children begin learning

mathematical concepts through activities like selecting objects from a set based on a common characteristic or sorting objects (Nodelman 2018; MK716 2018).

Research indicates that by the 5th grade, many students are already adept at using counterexamples and deductive reasoning to challenge propositions related to division and multiplication (Doruk, Doruk 2022). Understanding the structure of texts is essential for identifying examples and counterexamples; a few MLST topics are particularly relevant to this skill (Sondore, Beinaroviča, Daugulis 2023). Students in the 'Primary Education Teacher' program at DU require a gradual transition to various methodological techniques for teaching the new curriculum, which differs from their own experiences as students. One of the techniques is "questioning and answering". Questions are essential to stimulate thinking (Hačatřjana 2021). For example, the teacher's auxiliary questions for the student to see a way to complete or correct proof using counterexamples. "Why does your conjecture become false?", "Is there any part of your proof that breaks down in the case of counterexamples?", "What part of your proof can be applied to the case of counter-examples?", and "Can you invent a new conjecture by utilizing this part?" (Komatsu, 2010). The pupils themselves need to be able to ask questions, too. For example, pupils should create questions about the number 18. How many digits and what digits are in the number 18? The sum of which two even numbers is 18? The sum of which two equal numbers is 18? Can 18 be obtained by adding an even number and an odd number? The product of which two numbers is 18? The other methodical technique is to solve the task with different strategies. For example, there are some strategies for adding and subtracting numbers.

Using $a-(b+c)=a-b-c$, $38 - 23 = 38 - 20 - 3 = 18 - 3 = 15$;

strategy – "subtract gradually", $6\frac{2}{5} - 2\frac{3}{5} = 6\frac{2}{5} - 2 - \frac{3}{5} = 4\frac{2}{5} - \frac{3}{5} = 4\frac{2}{5} - \frac{2}{5} - \frac{1}{5} = 4 - \frac{1}{5} = 3\frac{4}{5}$;

Strategy – "increases both numbers equally", $6\frac{2}{5} - 2\frac{3}{5} = 6\frac{4}{5} - 3 = 3\frac{4}{5}$;

Strategy – "decrease both numbers equally", $6\frac{2}{5} - 2\frac{3}{5} = 6 - 2\frac{1}{5} - 6 - 2 - \frac{1}{5} = 4 - \frac{1}{5} = 3\frac{4}{5}$.

In evaluating which tasks and strategies within the competency-based curriculum relate to examples or counterexamples and are essential for improving language skills in the mathematics learning process, the following types of tasks have been identified:

1. Tasks requiring explanation, such as explaining a solution, an algorithm, or the reasons for an error.
2. Reasoning from specific cases to general principles.
3. Using a counterexample to determine the truth value of a proposition.
4. Tasks involving the application of visual, kinesthetic, and audial models.

For instance, consider these example tasks:

Task 1. (Explain the algorithm) Explain what it means to solve an inequality of the form $\frac{f(x)}{g(x)} > 0$ using the graphical technique of the interval method.

Task 2. (Reasoning from the specific to the general) Formulate the Divisibility Rule for 11.

Task 3. (Explain algorithms and reasoning from the specific to the general) Formulate and explain the algorithms for multiplying decimals and for dividing by 10, 100, 1000. Also, formulate and explain the algorithms for multiplying decimals and for dividing by 0.1; 0.01; 0.001. Describe the relationship between these algorithms. (Skola2030 2020)

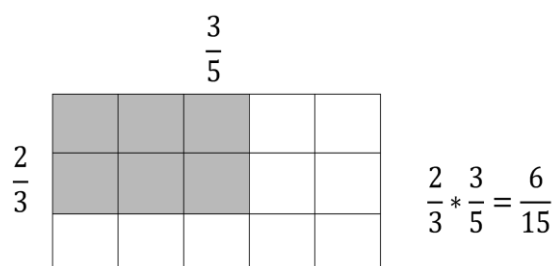


Figure 1. The visual model of the product of two proper fractions for Task 4

The next two tasks exemplify the use of visual models in mathematics. Task 4 is designed for 6th graders and focuses on the topic 'How to multiply and divide common fractions?'. In this task, a rectangle serves as the visual model. For instance, to find the product of proper fractions $\frac{2}{3}$ and $\frac{3}{5}$, students can calculate the ratio of the area of the shaded part of the rectangle to the entire rectangle, which is $\frac{6}{15}$, as illustrated in Figure 1. Task 5 involves a combinatorics problem where the general solution can be found using a graphical model, specifically a tree diagram. This diagram effectively simplifies the problem by using only four numbers instead of all seven, demonstrating a strategic approach to tackling combinatorics tasks.

Task 4. Geometrically model the product of two proper fractions.

Task 5. Ascertain the number of distinct two-digit numbers that can be formed using only the digits 1, 2, 3, 4, 5, 6, and 8, without repeating any digit.

Task 6. (Utilizing a counterexample to assess the truth value of a proposition). Evaluate the truthfulness of the statement: 'For a natural number to be greater than 60, it is sufficient for it to be greater than 40.'

Methodology of the survey and results

A case study design was developed, incorporating semi-open questions and the opportunity for respondents to create their own answers (Mārtinsonē, Pipere 2011; Geske, Grīnfēlds 2006). In December 2022, students from DU teacher programs (N=25) provided written responses, including the truth value of ten propositions, corresponding examples and counterexamples, and ten mathematical propositions suitable for 1st to 6th grade students. Both qualitative and quantitative analyses were employed in this study. It was observed that future mathematics teachers still encounter challenges in formulating mathematical propositions. While some propositions were derived from teaching resources, not all participants submitted ten propositions as requested. Other common errors included the use of definitions and interrogative sentences in place of propositions, as well as declarative sentences containing subjective terms like 'dislike' and 'like'. Additionally, issues were noted in sentence construction and the incorrect application of mathematical concepts.

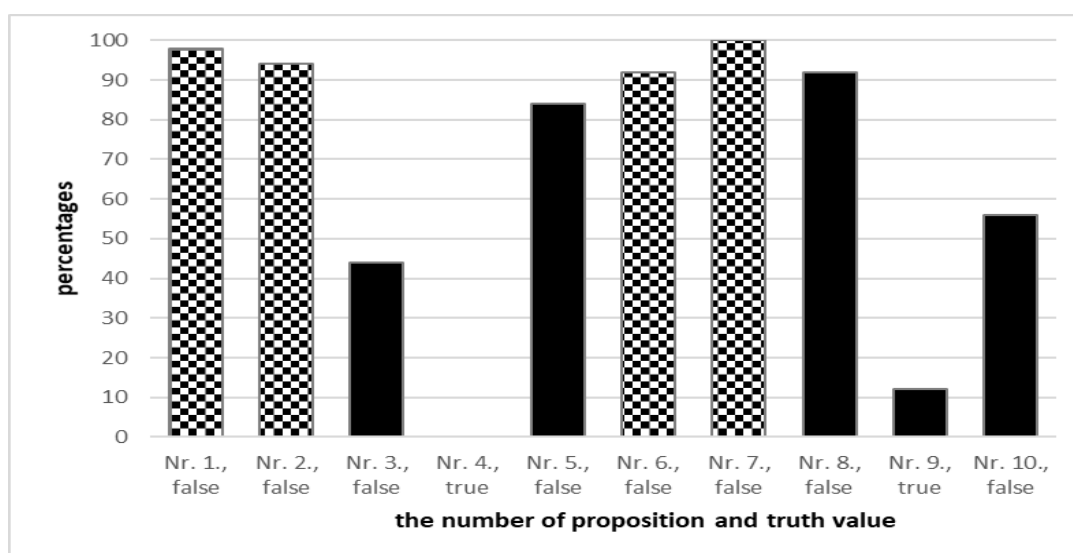


Figure 2. DU teacher study programs proportion of students who found a counterexample (in %)

Nonetheless, the respondents demonstrated adequate skills in determining the truth value of primary school-level propositions by effectively employing examples and counterexamples. Notably, over 80% of respondents successfully identified counterexamples for non-mathematical propositions (Nr. 1; 2; 4; 6; 7), as illustrated in Figure 2. The black bars in Figure 2 indicate difficulties faced by respondents in finding counterexamples for certain mathematical propositions. For instance, only 44% of respondents provided correct counterexamples for proposition Nr. 3, which may be attributed to a lack of understanding of concepts such as “divide” and “even number”. Interestingly, proposition Nr. 9, a true mathematical statement that logically cannot have counterexamples, was mistakenly challenged by 12% of respondents, as shown in Figure 2.

Conclusions

The enhanced mathematics curriculum places significant emphasis on the understanding and meaningful application of mathematical concepts and graphic symbols, logical reasoning and substantiation of statements, as well as the ability to ask questions and construct examples. Research examining the language behavior of future mathematics teachers reveals difficulties in formulating mathematical propositions. This finding highlights the need for task types specifically designed to improve the language skills of these future educators. Constructing examples and counterexamples is identified as a critical tool for developing such skills. Teachers must be adept at posing questions, listening to students' responses, providing corrections, and assigning relevant tasks. To this end, the authors recommend employing four types of tasks that foster language development in mathematics: tasks that require explanation; tasks involving reasoning from specific instances to general principles; tasks using counterexamples to assess the truth value of propositions; and tasks that involve the application of visual, kinesthetic, and audial models.

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BIOLOĢIJA / BIOLOGY

DEVELOPING SCIENCE STUDENTS' WATER LITERACY THROUGH miniSASS

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Abstract

DEVELOPING SCIENCE STUDENTS' WATER LITERACY THROUGH miniSASS

Key Words: *Water literacy, Curriculum, Science, Water quality*

Environmental education and sustainability address the survival of learners in their own environment. Water is a critical part of the environment in the context of the study. This exploratory study investigates the effects of a version of Stream Assessment Scoring System (miniSASS), in the teaching and learning of science in the formal classroom teaching, in one secondary school. The study responded to the research question: What water literacy competences are developed among grade 11 science students, with the use of miniSASS? Water literacy theory was used to guide the study. Qualitative approach was employed in the form of Action Research (AR) methodology.

Fifty-two students participated in the study. Participatory observation and semi-structured interview instruments were employed to collect data. The findings show that numerous water literacy competences were developed among grade 11 science students, with the use of miniSASS. These include: Connectedness and familiarity with water, knowledge of safety and quality of water, ability to identify water-related problems and willingness to solve water-related problems. It is, therefore recommended that curriculum developers, education policy makers, Ministry of education and training, Ministry of water and Ministry of Tourism, Environment and Culture and other government ministries should integrate miniSASS in their programmes, in order to improve water literacy among the youth on sustainability of the streams.

Abstrakts

Atslēgvārdi: *Ūdens pratība, Mācību programma, Zinātne, Ūdens kvalitāte*

Vides izglītība un ilgtspēja pievēršas izglītojamo izdzīvošanai savā vidē. Ūdens ir būtiska vides daļa pētījuma kontekstā. Šajā pētnieciskajā pētījumā tiek pētīta Stream Assessment Scoring System (miniSASS) versijas ietekme uz dabaszinātņu mācīšanu un mācīšanos formālajā mācīšanās klasē vienā vidusskolā. Pētījumā tika atbildēts uz pētījuma jautājumu: Kādas ūdens pratības kompetences tiek attīstītas 11. klases dabaszinātņu skolēnu vidū, izmantojot miniSASS? Pētījuma vadīšanai tika izmantota ūdens pratības teorija. Kvalitatīvā pieeja tika izmantota Action Research (AR) metodoloģijas veidā.

Pētījumā piedalījās piecdesmit divi studenti. Datu vākšanai tika izmantoti līdzdalības novērojumi un daļēji strukturēti intervijas instrumenti. Iegūtie dati liecina, ka 11. klases dabaszinātņu skolēnu vidū tika attīstītas daudzas ūdens pratības kompetences, izmantojot miniSASS. Tie ietver: ūdens saistību un pārzināšanu, zināšanas par ūdens drošību un kvalitāti, spēju noteikt ar ūdeni saistītās problēmas un vēlmi risināt ar ūdeni saistītās problēmas. Tāpēc ir ieteicams, lai mācību programmu izstrādātāji, izglītības politikas veidotāji, Izglītības un apmācības ministrija, Ūdenssaimniecības ministrija un Tūrisma, vides un kultūras ministrija, kā arī citas valdības ministrijas savās programmās integrētu miniSASS, lai uzlabotu jauniešu zināšanas par ūdens patēriņu par straumju ilgtspēju.

Introduction

Lesotho has an enabling policy and conventions framework for environmental sustainability initiatives. As part of the UN global community, Lesotho is committed to protecting the planet and creating sustainable livelihoods for all, by adoption of 17 Sustainable Development Goals in 2015 (United Nations 2015; United Nations 2021). Sustainable development was first defined by the World Commission on Development and Environment as development that meets the needs of the present generation without compromising the ability of future generations to meet their own, (United Nations, as cited by Emas 2015). The present study focused on water literacy development of the students. It thus focused mainly on Sustainable Development Goal (SDG) 6 which calls for availability and sustainable management of water and sanitation for all. Additionally, Lesotho ratified Ramsar

Convention in 2004; the convention was agreed in 1971 between 18 nations, in Iran and it is the only global treaty that focuses specifically on wetlands (Skov 2015). The attempts to implement the Convention, however, have been hampered by an inherent lack of capacity at individual, institutional and systemic levels (Ministry of Tourism, Environment and Culture 2007).

As a member of the Southern African Development Community (SADC), Lesotho is party to the SADC policy and strategy for Environment and Sustainable Development (Ministry of Environment 1998). The country also has the National Environment Policy (1998) in place which states an objective to use and conserve the environment and natural resources for the benefit of present and future generations. In line with the policy, The Curriculum and Assessment Policy, calls for education that equips learners with skills in conserving and maintaining their environment for the benefit of all (Ministry of Education and Training 2008).

With respect to this policy framework, there is a need for schools to play a big part in the protection of natural resources, such as water. In this study, the action research was employed to connect students with stream water and so promote its protection, with the use of miniSASS in the teaching of science amongst grade 11 science students. The study was guided by the research question: What water literacy competences are developed, among grade 11 science students, with the use of miniSASS?

LITERATURE REVIEW

While it has capacity to benefit students, there is little literature in the Lesotho context on outdoor education effects in science learning. Thus the researchers set out to investigate the impact of miniSASS in the development of the students' water literacy competencies. In a recent review of the Sustainable Development Goals miniSASS was profiled as a global example of best practice towards Sustainable Development Goal 6 on Water and Sanitation (Hoffmann and Gorana 2017). MiniSASS is a simple tool which can be used by anyone to monitor the health of a river. It involves the collection of a sample of macroinvertebrates from the stream, and depending on which groups are found, one can measure the general river health and water quality in that river, based on identification of just thirteen macro-invertebrates. Graham (2012) argues that miniSASS teaches those using it about scientific inquiry; as individuals have to systematically and accurately follow instructions and collect data, analyse and display it. Hradsky (2021) findings indicate that students taken outdoors frequently are more likely to establish connections with nature and their own community, creating better stewardship habits. It is crucial to integrate water education in the teaching of science in order to develop water literacy competencies as water literacy and willingness to change are shaped by educational exposure and personal experiences (Johnson & Courtney 2020). Teaching and learning

about water in an array of contexts, is pivotal to help future water researchers, practitioners, and global citizens develop water literacy (Mostacedo-Marasovic et al. 2022).

THEORETICAL FRAMEWORK

Water literacy theory (Otaki et al., 2015) was used to guide the present study. He (2018) argues that water literacy is a composition of the necessary water knowledge, scientific water attitude and the exemplary water behaviour. Whereas, McCarroll and Hamman (2020) define water literacy as the culmination of water-related knowledge, attitudes and behaviours, setting apart its importance and uniqueness from other more commonly used labels such as ‘ecological literacy’ and ‘environmental literacy’. Contrary to the latter theories, water literacy means having an understanding of the significance of water in life and understanding where water comes from and how to use it (Ramgoolam 2016). In accordance with McCarroll and Hamman (2020), students’ understanding of water literacy and conceptions, as well as their alternate, limited, naïve or misconceptions, is a critical basis for designing effective education programs and interventions.

Floress et al. (2017) warned that a failure to understand how water resources are provided and maintained decreases people’s willingness to protect them. Otaki et al. (2015) assert that being water literate means understanding how the water we use daily is delivered and treated, as well as knowing the quality and safety of that water, and how much we use daily and exactly what we use it for. Water literacy is key to the students’ awareness of their immediate environment, as Otaki et al. (2015) put it:

Water literacy is effective because it enables students to re-evaluate local water systems and water usage, it schools the citizens who are able to associate daily life with social issues and it contributes to the recovery of a variety of relations between water and humans (p.40).

Wood (2014) re-emphasize that a water literate citizen is someone who is informed and knowledgeable about water use and issues and applies this knowledge to their values and their actions, whether that is achieved actively or subconsciously. Applying the understanding by making responsible decisions about natural resources is essential for water literacy (Laporte et al. 2013).

Based on this reviewed literature, the key tenets of water literacy may be summarised as follows: knowledge of safety and quality of water, connectedness and familiarity with water, knowledge of water sources, treatment and efficient uses of water, ability to identify water related problems and to willingly take action to solve them (Lenonya & Mokuku 2021).

The water literacy theory was applied in the present study due to its potential to involve students in all the activities that will take place in the process of exploring the use of miniSASS in the teaching of science. The theory has learner-centred features, in which the learners are active in

the learning process and get involved in the real world in solving community-based environmental problems.

METHODOLOGY

Method and Design of Study

This is qualitative design study that employed an Action Research (AR), case study, method (Cohen et al. 2018). Action research is a “systematic collection and analysis of data for the purpose of taking action and making change” by generating practical knowledge (Gillis & Jackson 2002: 264), through a cyclical and recurring process of planning, action, monitoring and reflection.

Research Participants and Procedure

52 grade 11 students participated in the study: the class comprised of 30 females and 22 males. Students were divided into Group1 and Group2. The two groups implemented the miniSASS activity at a stream that was about 20minutes walk from the school. The activity involved: sampling of micro-invertebrates using SASS nets (See Figure 1 below) and a white container was used for placing collected species; samples were done on the sand and rock biotopes. Identification of collected organisms was done using “Species Identification Sheet’ (See Figure 2 below) and a ‘Dichotomous Key’ aided with the of a hand lens. Data was analysed, interpreted and the results recorded on the worksheet. Each group did the activity twice based on the two cycles of Action Research, and at least three members from each group sampled, while the other members were involved in other activities during the miniSASS activity (i.e. identified invertebrates, took pictures).



Figure 1. **Students taking a Sample**



Figure 2. **Students identifying collected sample**

Data Collection Tools

With the permission of the learners, the participant observation (Kawulich 2005) was used to record the events, behaviours and objects, at various phases of the Action Research process using the

video and audio cellphone recorders; the field notes were also taken during the various phases of the miniSASS activities. In addition, interviews (Gillis & Jackson 2002: 466) were used to elicit information from students; ten students were selected to respond to a set of questions that investigated whether students liked miniSASS and reasons for liking it, what learning gains they have acquired, as well as what safety measures are to be considered before and during miniSASS activity and these were recorded.

Data analysis

The researcher familiarised himself with the data by reading and re-reading and searching for meaning and identifying pieces that have value (coding). The tally marks were used to count the number of times the theme emerged and were analysed in frequency forms. The themes emerging from the data were developed in relation to the theoretical framework and to the research questions.

Findings

The findings are presented in terms of the emerging competences that learners developed through the implementation of the two cycles of Action Research (AR).

Knowledge of Water Safety

In the first AR cycle the researcher observed that many students in the Group1 did not have gumboots on for protection from injuries while walking in water and that only a few of them did in the second group. The researcher had advised them to bring gumboots for the fieldtrip. While this might have indicated that students had no gumboots at home, it also showed that they underestimated the risk of possible injuries in the stream. After the second cycle of the AR, a small sample of students, from the class, were interviewed on the safety measures to be considered before and during the miniSASS activity. The responses were displayed in the manner illustrated in the table below.

Table 1. **Students' views on the safety of the river water**

Water safety precautions	Number of students N=10
Wearing gumboots	8/10= 80.00%
Never sample alone	8/10 = 80.00%
Never sample when river is full	3/10= 30.00%
Wear safety clothes	8/10=80.00%
Observing river depth before sampling	2/10=20.00%
Using stick to check depth of water	1/10=10.00%
People sampling must fasten each other with a rope if river has more water	1/10=10.00%
Wearing life jacket	1/10=10.00%

It can be noticed, from table 1 above that “wearing gumboots”, “never sampling alone” and “wearing safety clothes” were the most frequently mentioned water safety measures, with 80.00% frequency, when sampling in the river. Generally, through the miniSASS activity, students’ knowledge on safety measures was sound and generic, and applicable to safety in relation to any water bodies.

Knowledge of Water Quality and Connectedness with the Stream

The students found that the miniSASS scores, in both AR cycles 1 and 2, indicated that the Phuthiatsana River was in its ‘natural conditions’. During the sampling the connected with the stream by entering into it and exploring its life forms. Tables 2 and 3 below show the organisms that they collected, observed, identified and recorded in their worksheets in the cycles 1 and 2.

Table 2. The macro-invertebrates that the students collected in the stream during miniSASS

Invertebrates Students Identified in the First Cycle	Invertebrates Students Identified in the Second Cycle
Stoneflies	Crabs or Shrimps
Minnow mayflies	Stoneflies
Dragonflies	Bugs or Beetles
Bugs or beetles	Dragonflies
Caddisflies (cased and uncased)	True flies
True flies	Caddisflies (cased and uncased)
	Minnow mayflies

Table 3. miniSASS water quality interpretation table

Ecological category (Condition)	River category	
	Sandy type	Rocky type
Unmodified (NATURAL condition)	> 6.9	> 7.9
Largely natural/few modifications (GOOD conditions)	5.8 to 6.9	6.8 to 7.9
Moderately modified (FAIR condition)	4.9 to 5.8	6.1 to 6.8
Largely modified (POOR condition)	4.3 to 4.9	5.1 to 6.1

Seriously/critically modified (VERY POOR condition)	< 4.3	< 5.1
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Source: Adapted from miniSASS (www.miniSASS.org) (2013).

The scores obtained by all groups were all > 6.9, except in the Group 1 where the sensitivity score was found to be 6.5, which meant that Phuthiatsana stream water was in ‘good condition’. This was despite all the solid waste the students found in and around it. The findings of the two groups in both the first and second cycles, generally, meant that Phuthiatsana river water was unmodified (in ‘natural condition’).

The researchers observed that in the second AR cycle, student could collect invertebrates from stones using their hands without any fear that they could harm them; in the process, they got familiar with the aquatic habitats of the invertebrates (Field notes, 05/05/2021 and 12/05/2021). Reflecting in the process in an interview, one student stated: “I have learnt how to collect, analyse and interpret data using the insects from the river”; one student when asked what she/he liked about miniSASS in an interview responded: “I liked miniSASS activity because it taught us about testing water quality of the stream”. In response to the same question, one student explained “I like miniSASS because I am now able to identify the organisms living in the stream and can tell whether stream water is in good condition or not”.

Ability to Identify Water-Related Problems

Fifty-two (52) students, from both Groups 1 and 2 were asked to identify the Phuthiatsana stream pollutants, after the two AR cycles, and their responses to the question are illustrated in Figure 3 below.

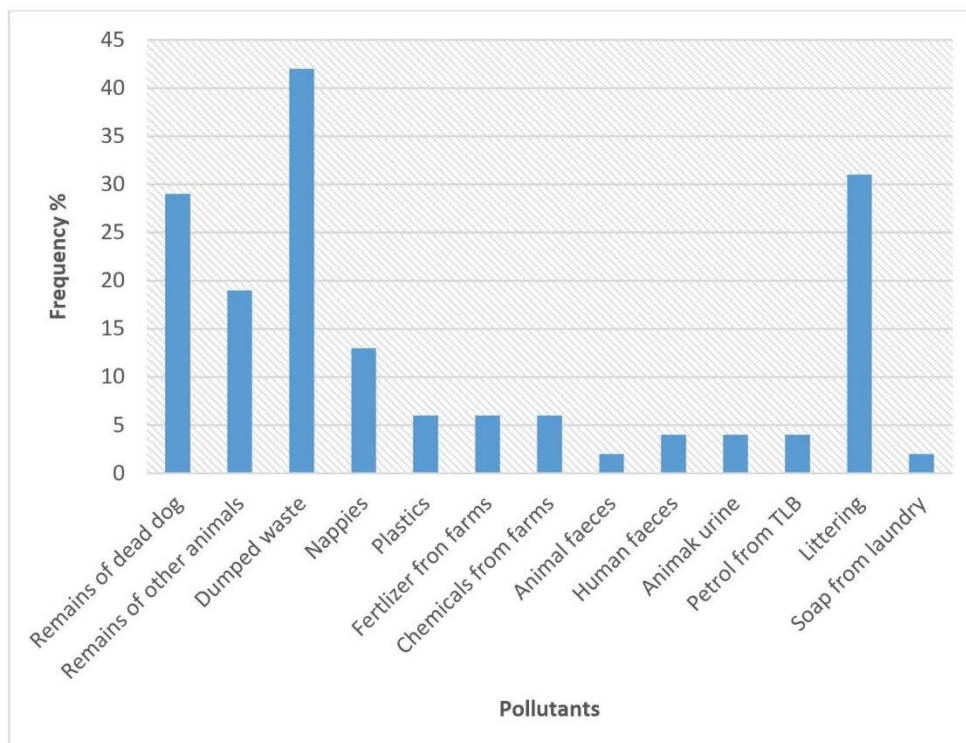


Figure 3. **Pollutants affecting Phuthiatsana stream**

From Figure 3 above, the frequently mentioned pollutant (42%) is dumped waste along and in the river. Littering is the second most (31%) identified pollutant affecting the north Phuthiatsana river. Twenty-nine percent of the students mentioned remains of the dead dog as the pollutants they have identified next to the stream. Most of the pollutants are associated with the river under study being turned into a dumping site, with the exception of fertilizer, farm chemicals, animal and human faeces, animal urine, and soap from laundry, which are not necessarily disposed of as waste. In an interview, after the two AR cycles, students were asked of the learning gains they obtained during miniSASS activity, and one student stated: “I have learned of the pollutants, thrown along the river by people, which may affect river water badly”. Another student explained: “I have learned of sources of water problems”, and another one: “I have learned of the problems affecting the stream”. This indicated the students’ recognition and concern about the dumping of the solid waste in the stream, despite their discovery that the stream water being in its ‘natural condition’, in terms of the miniSASS score.



Figure 4. Solid waste dumped along the Phuthiatsana stream

Willingness to take action to solve stream-related problems.

Following the miniSASS experience, the students were asked what actions they could take in order to prevent and control pollution problems facing the Phuthiatsana stream. This was to determine their willingness to solve problems facing the river under study, based on their appreciation of the environmental problems they identified during miniSASS activities. Table 4 below shows students' responses to the question "what actions could you take to solve problems facing Phuthiatsana stream?"

Table 4. Students' mentioned possible actions to solve identified problems facing Phuthiatsana River

Actions students could take	Number of students per action N=52
Collecting waste materials for recycling	9/52=17%
Teaching people about danger of dumping next to the river	1/52=2%
Fencing an area of the river where dumping takes place	31/52=60%
Writing on notice boards near the river that "no dumping is allowed"	7/52=13%
Removing all the garbage thrown next to the river.	11/52=21%
Encouraging government to put dust bins next to the river	3/52=6%
Advising government to have security Guard at the place where dumping occurs near the river	5/52=10%
Encouraging farmers to use organic manures instead of fertilizers	7/52=13%
By arresting people littering next to the river	2/52=4%

Reporting people littering to the police	4/52=8%
Advising farmers (parents) to stop using herbicides and pesticides.	11/52=21%
Teaching farmers about crop rotation to control pests and to improve soil fertility without using chemicals.	8/52=15%

It can be noted from Table 4 above that the largest number of students (60%) stated that they would opt for fencing an area where dumping takes place to prevent further dumping. The second most frequent action students were willing to take, at 21%, concerned their willingness to advise farmers to stop using herbicides and pesticides and to remove garbage thrown next to the Phuthiatsana River. On the other hand, 17% of the students stated that an action they could take was to collect dumped waste for recycling.

In general, miniSASS activity engendered in students the willingness to take action to solve stream related problems, albeit not directly on the basis of the miniSASS water quality scores, but through the students' exposure to and familiarisation with the stream. In an interview, when asked what they liked about miniSASS, one student explained "I have now realised that I can take initiative to take care of my nearby environment. Avoid water pollution and explain to those who are not aware, polluting the environment". While miniSASS might have raised students' awareness on some actions to take to solve problems facing the stream, the miniSASS itself, was not mentioned by students as an 'action' that they could take to solve problems that the Phuthiatsana River faces.

Discussions

This study shows that there is some evidence of students' development of the water literacy competencies, as in terms of knowledge of aspects of water safety, knowledge of water quality parameters and connectedness with water, identification of water related problems, as well as willingness and ability to take action to solve water related problems.

Safety Knowledge

Waite and Goodenough (2018) express the need to make learners feel safe before taking them off-site to an outdoor learning environment. While students, in both cycles of the AR in the present study failed to bring their protective boots (gumboots), they developed some generic knowledge on water related risks and prevention thereof. They appreciated risks associated with being in an active stream, such as hazardous objects on the river floor, and the need to test river depth using a stick,

before one can enter it. Kruger (2020)'s argues that students should learn of safety during miniSASS, and know for instance that crabs can pinch if chased away from their habitats and that eating fish from dirty water would make them sick. The risks that the students were introduced to were however limited to the physical impact of the stream on them, and not organisms and health related.

Water Quality Knowledge & Connectedness with the Stream

During the miniSASS activity, students argued about the quality of Phuthiatsana river water, in light of the observed solid waste (e.g. used nappies, rusty water pipe). This suggests that students' knowledge on water quality issues deepened, as well as their awareness of deposits that could worsen river water quality. Knowledge on water quality is at the core of world water issues; and water quality is a key concern as it is used for drinking and domestic purposes, irrigation and as a habitat for aquatic life (Uddin et al. 2014). The miniSASS activity gave students the opportunity to interact with the stream water and the aquatic life, and thus appreciated its quality, in the process of sampling. They were familiarised with seven of the 13 listed miniSASS species; five in the first cycle and seven in the second cycle of AR. Barnett et al. (2018) assert that the degree to which students are aware of water quality is linked to how they interact with and experience water e.g. drinking water, engaging in outdoor recreation. Students' environmental awareness in terms of quality, is significant in that water pollution remains a major challenge in today's world and addressing it has become the top priority for sustainable development (Ezbakhe 2018).

The findings are in alignment with Singh et al. (2018), who claim that miniSASS is an appropriate tool for understanding the concept of water quality and allowing pupils "get their hands dirty". Taylor et al. (2021) further assert that through miniSASS one can learn about rivers, monitor water quality, explore the drivers of water quality deterioration, and take action to improve the quality of the streams and rivers.

Ability to identify water-related problems.

The miniSASS results provided a rather contradictory results of the Phuthiatsana stream as in 'natural condition', yet there was much solid waste in and around it. This seemed to ignite a healthy among some students about the actual health state of the river. One student argued that Phuthiatsana could not be said to be of 'good quality' yet there were dumped used nappies seen in water, in their interpretation of the score obtained based on the organisms found. Although the purpose of the miniSASS, in this case, was to determine the quality of the stream water, and not necessarily to identify the factors that affected the water quality, students managed to observe and discover some of river water-related problems spot on, such as the nappies in water and metallic water pipe. Thus students could see a bigger environmental picture as result of the miniSASS (Graham 2012).

Willingness to take action to solve stream related problems.

The findings indicated that students were able to suggest viable means of protecting Phuthiatsana stream, albeit not based on the miniSASS scores they obtained. The basis for their suggested solutions could be attributed, instead, to their experiential exposure to the sources of pollution, during the miniSASS activity. This is supported by Singh et al. (2018) that miniSASS is done with the hope that students would be motivated to adopt the streams and become responsible for their conditions. A suggestion by most students (60%) that the dumping area around the stream be fenced, impracticable as it sounds, demonstrate how concerned and solution seeking students were. Kruger (2020) contends that miniSASS enhances Self-Directed Education which prepares students to adapt and problem-solve in changing societies, but also crucial to ensure a healthy environment for people and life of biodiversity.

Conclusion

This study shows that miniSASS has the potential to develop water literacy competences among students. The grade 11 science students participating in this study showed evidence of a range of water literacy competencies after engagement in the miniSASS activities, with the use of Action Research (AR). These competences, to varying degrees, were; Connectedness and familiarity with water, knowledge of safety and quality of water, ability to identify water-related problems and willingness to solve water-related problems. Water is one of the important 2030 SDGs that need be attended to and is stated under SDG 6 as, 'Clean Water and Sanitation'. The integration of miniSASS activity in science teaching, can enable the deepening of learners' understanding of the abundant aquatic environment in Lesotho, and to actively contribute to the solution of the widespread pollution of wetlands in this context.

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