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INACTIVITY—THE SLOW BUT CERTAIN PATH TO CARDIOVASCULAR DISEASE

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Abstract

Cardiovascular diseases (CVD) remain the leading cause of global mortality, with Romania classified as a high cardiovascular risk country. Sedentary behaviors and obesity, closely interrelated factors, significantly contribute to the increased CVD risk. This study analyzed 45 subjects aged between 18 and 49 years, none of them being a professional athlete. Data collected included sex, age, BMI, metabolic equivalents (METs), and predictive values for the age and sex of the patient. The study aimed to evaluate the relationship between these variables and to assess the situation regarding the incidence of sedentary lifestyle. Only 18% of the subjects demonstrated an increased exercise tolerance. Approximately 50% were overweight, and 26% were obese. Subjects with normal BMI showed greater exercise tolerance compared to overweight and obese individuals. Overall, 82% of participants did not meet the ESC guidelines for physical activity. The low levels of physical activity highlight the urgent need for national educational and structural interventions to reduce cardiovascular risk and promote an active lifestyle, particularly among vulnerable groups such as young people and overweight individuals.

Key Words: sedentarism, cardiovascular risk, obesity, metabolism.

INTRODUCTION

Cardiovascular diseases (CVD) remain the leading cause of mortality worldwide (Di Cesare M, 2024). In Europe, and particularly in Romania—classified as a very high cardiovascular risk country according to the Systematic Coronary Risk Evaluation (SCORE 2021) developed by the European Society of Cardiology (ESC) (JI, 2019; collaboration, 2021)—this classification highlights the urgent need to mitigate the

already elevated cardiovascular risk by adopting proper dietary habits and regular physical activity. Unlike low-risk countries, where other factors may compensate for a lower baseline risk, in Romania, the combination of sedentary behavior, obesity, and other modifiable risk factors significantly increases the likelihood of developing cardiovascular diseases.

Insufficient physical activity is recognised as one of the most important modifiable risk factors for CVD, alongside smoking, hypertension, obesity, and dyslipidemia (Lavie CJ, 2019). Physical exercise plays a significant role not only in preventing cardiovascular diseases but also in improving the prognosis of individuals already diagnosed with cardiovascular pathologies. One key benefit is the promotion of collateral circulation, which can improve both symptoms and long-term outcomes (R., 2022).

Previous studies have demonstrated that an active lifestyle offers significant cardiovascular health benefits, such as lowering blood pressure, improving endothelial function, and preventing the progression of atherosclerosis (Lavie CJ, 2019).

Additionally, the updated guidelines from the European Society of Cardiology recommend a minimum of 150 minutes of moderate-intensity or 75 minutes of high-intensity exercise per week for primary and secondary prevention of cardiovascular diseases (Frank L J Visseren, 2021). Despite these recommendations, physical activity levels remain insufficient in the general population, with the prevalence of obesity tripling over the past 4–5 decades (Nichols, 2023). In 2022, approximately 14% of men and 18.5% of women were classified as obese. These increases are attributed to dietary shifts toward high-calorie, processed foods and reduced physical activity, particularly in urbanized environments and high-income countries (Nichols, 2023).

The purpose of this study is to emphasize the importance of implementing nationwide educational and awareness programs to encourage the population to adopt an active lifestyle by integrating regular physical activities into daily routines. Given the significant impact of inactivity on cardiovascular risk, the study highlights the necessity of structural and educational interventions to promote physical exercise as an effective tool in preventing cardiovascular diseases. Through these measures, the aim is

to mitigate the risks associated with sedentary behavior, improve public health, and foster healthier behaviors, particularly among high-risk populations.

METHODOLOGY

This study was conducted after obtaining informed consent from participants and receiving approval for the study protocol from the Ethics Committee of "Dunărea de Jos" University in Galați.

We analyzed the exercise ECG tests of 45 subjects. The tests were performed at the "Aristide Serfioti" Military Emergency Hospital in Galați between January 1, 2022, and December 1, 2024, using an ergometer bicycle, following the Bruce protocol (Vilela EM, 2023). Exclusion criteria included age under 18 or over 49 years and a history of performance training, as the study focused on the general population.

The collected data, highlighted in Table 1. Collected Data, included participants' sex, age, body mass index (BMI), metabolic equivalents (METs), age-predicted values, maximum systolic blood pressure, heart rate and reason for termination.

Table 1. Collected Data

Name	Age	BMI	METs	MaxR	MaxBP	Reason for termination
X	**44**	**35,7**	**6,6 (56%)**	**153**	**213/110**	**Muscle fatigue**

RESULTS

Distribution by Body Mass Index (BMI):

Only approximately a quarter of participants (11, 24.4%) had a normal BMI, half were overweight (48.8%), and a quarter were obese (26.6%)

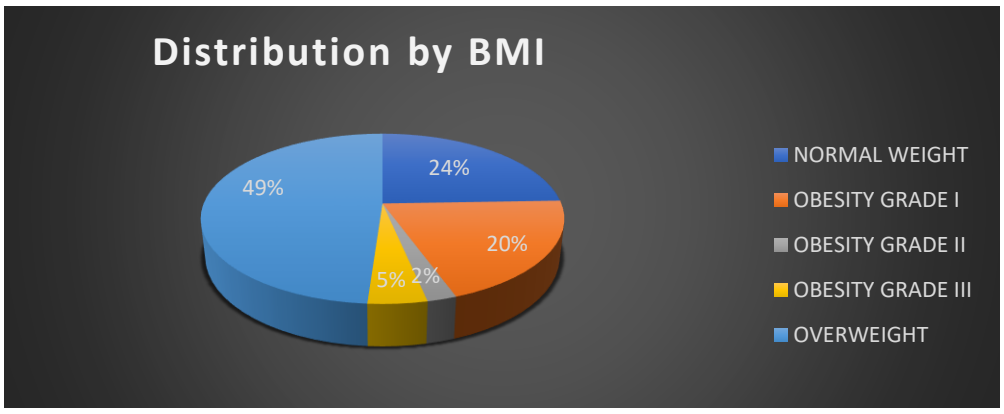

Figure 1: Distribution by BMI

Exercise capacity:

Patients were classified based on the ratio of the number of METs achieved to the predicted value for their sex and age. A predicted value below 60% denotes low tolerance, while a value above 80% indicates high capacity. Middle values, between 60% and 80%, were classified as moderate tolerance.

After evaluating the exercise tests, increased tolerance was observed in only 18% of the subjects. 55% had moderate tolerance, while the remaining 27% displayed low tolerance.

The term "moderate" attributed to the intermediate category can be misleading, as it does not necessarily indicate a normal exercise capacity. As a reference, a minimum of 3 training days per week is required to ensure high exercise tolerance (Kharabsheh SM, 2006).

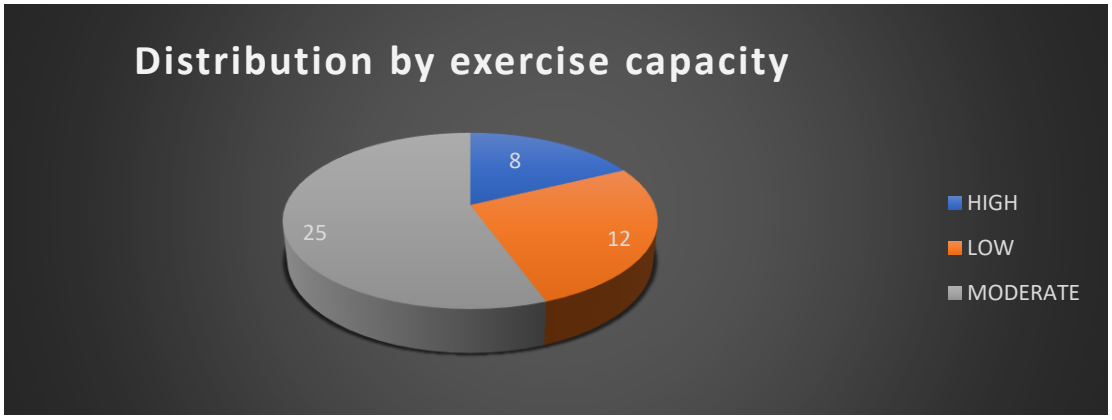

Figure 2: Distribution by exercise capacity

The relationship between BMI and METs:

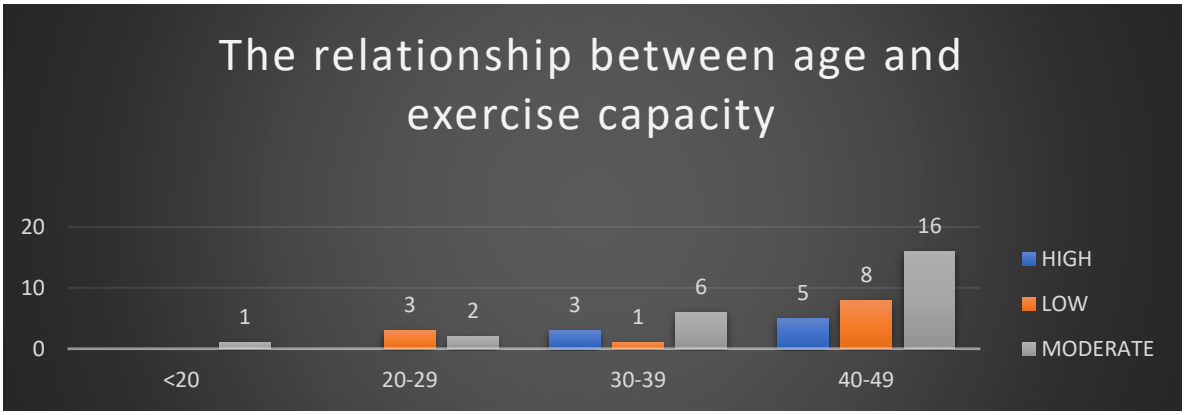

Figure 3: The relationship between BMI and METs

Age Group Distribution:

The majority of patients (65%) were in their 40s. 22% of the subjects were aged between 30-39 years, 11% between 20-29 years, and only 2% were between 18-20 years old.

In the 20-29 age group, no cases of high tolerance were recorded. 3 out of 5 (60%) had low tolerance, and 40% had moderate tolerance. Among participants aged 30-39 years, the majority (60%) had moderate capacity, 30% had high tolerance, and 10% had low tolerance. In the oldest age group (40-49 years), 55% had moderate capacity, 17% had high, and 28% had low tolerance.

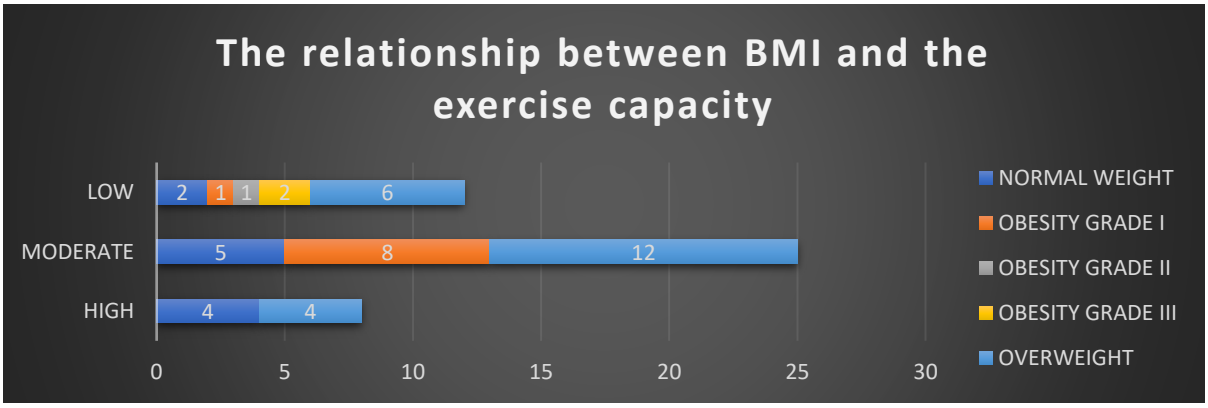

Figure 4: The relationship between BMI and the exercise capacity

No cases of low tolerance were found among subjects with a normal BMI. They were equally divided between the other two categories. Among overweight participants, 4 (8.8%) had high tolerance, 12 (26.6%) had moderate tolerance, and 6 (13%) had low tolerance. Among the obese participants, the majority (75%) had moderate tolerance, while 25% had low tolerance.

The relationship between sex and exercise capacity:

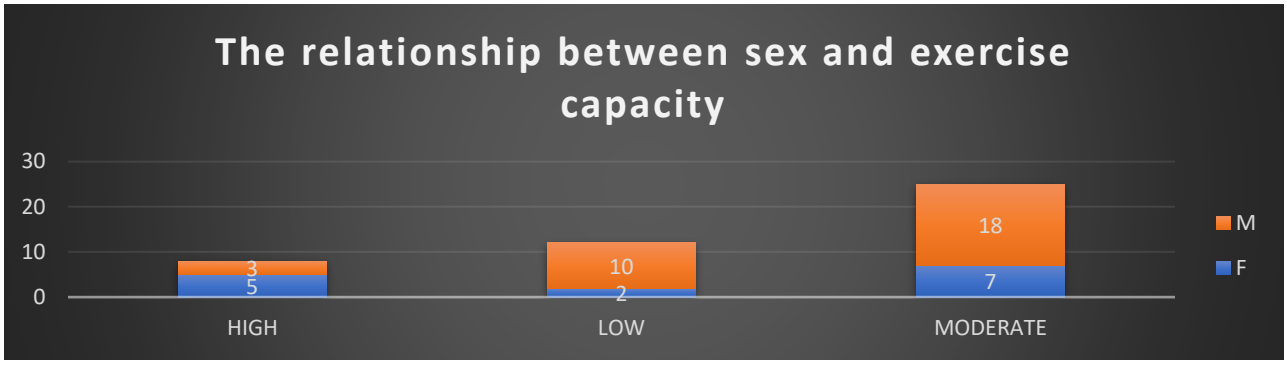

Figure 5: The relationship between sex and exercise capacity

Female subjects accounted for 31%. Of these, 50% had moderate capacity, 35% had high capacity, and the remaining 15% had low capacity. Male subjects, making up 69%, mostly (58%) had moderate capacity. Only 9.6% of them had high capacity, while 32% had low capacity.

Reason for termination:

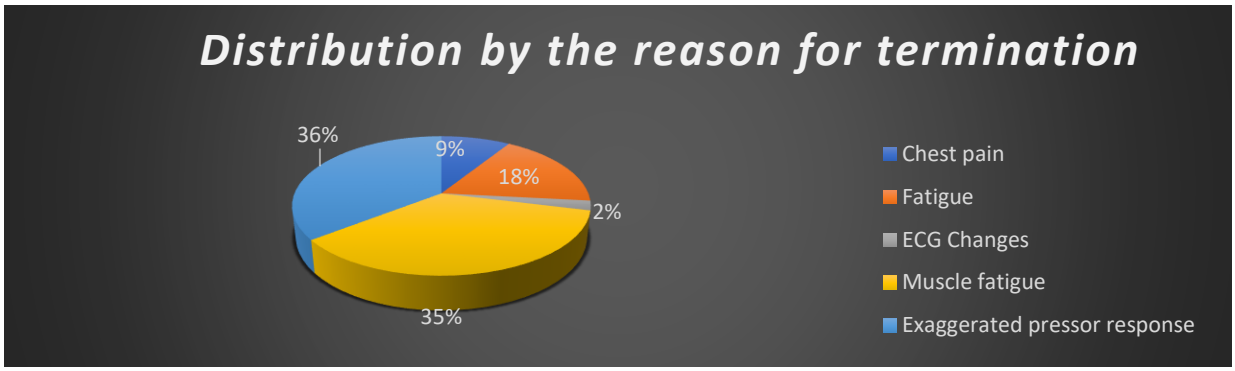

Figure 6: Distribution by the reason for termination

The most frequent reason for exercise test termination was an exaggerated pressor response, in 36% of cases, followed closely by muscle fatigue (35%), fatigue (18%), the onset of chest pain, with or without anginal characteristics (9%), and ECG changes suggestive of myocardial ischemia (1%).

DISCUSSION

The results of our study highlight a concerning trend regarding the low level of physical activity, especially among young people, where reduced exercise tolerance was more pronounced. This finding aligns with trends reported in other international studies, which indicate a progressive decline in physical activity levels among younger

generations, associated with an increase in sedentary behaviors, such as excessive use of electronic devices and reduced time spent on structured physical activities (Barnett TA, et al., 2018).

The correlation observed between overweight and reduced exercise tolerance has been observed in other studies in the literature (Powell-Wiley TM, et al., 2021). Studies have shown that a high body mass index negatively influences physical performance, both by increasing metabolic load during exercise and by frequently being associated with comorbidities such as hypertension or dyslipidemia (R., 2022). In contrast, high exercise capacity can act as a protective factor, preventing excess weight accumulation and improving long-term cardiovascular health (Lavie CJ, 2019). In this study, none of the participants with high tolerance were classified as obese, highlighting the significant benefits of regular physical exercise.

A notable aspect is the sex difference, with women having higher exercise tolerance compared to men. Although this result may be influenced by a relatively small number of participants and their distribution by age or activity level, it is an aspect that requires further investigation to better understand the physiological and behavioral differences between gender in relation to physical activity.

Among the limitations of the study is the geographical area, restricted to the southeast of Romania, as socio-demographic characteristics and lifestyle habits can vary significantly between regions of the country. Future studies could extend the analysis to a national level for a more representative picture. Another limitation is the lack of concurrent pulmonary monitoring, such as in cardiopulmonary exercise testing, which can estimate maximal oxygen consumption, providing a more accurate assessment of exercise capacity (Razvi Y, 2023) (Green GK, 2023).

The ESC guidelines for physical exercise are clear: at least 150 minutes of moderate activity or 75 minutes of intense activity per week are essential for reducing cardiovascular risk (Frank L J Visseren, 2021) (Sanjay Sharma, 2021). However, 82% of the study participants did not meet these standards. This highlights the need for public health measures to promote physical activity, including educational campaigns and

accessible community programs, to combat sedentary lifestyles and reduce the associated cardiovascular risk.

In only 10% of cases, the test was stopped due to symptoms suggestive of myocardial ischemia. In the remaining 90% of cases, the reasons for termination were attributed either to the inability of the peripheral vascular system to adapt to the exercise demands, reflected by excessive increase in peripheral resistance, or the presence of muscular or myocardial deconditioning, manifested through muscle fatigue or fatigue. Both the vascular bed and the myocardium and skeletal muscles can gradually adapt to exercise, but this requires regular physical exertion (Pedralli ML, 2020). Maintaining a sedentary lifestyle will eventually lead to these individuals transitioning into the other 10%, where atherosclerosis has already become manifest (Alexander Y, 2021).

Our study contributes to a better understanding of the impact of sedentary lifestyles on cardiovascular health, emphasizing the need for tailored interventions for targeted groups, such as young people and those who are overweight, to improve overall health and quality of life.

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SUDDEN DECREASE IN EXERCISE TOLERANCE—A CASE STUDY ON ANOCA

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Abstract

This case study describes the evolution of a 45-year-old patient who presented to the hospital with a severe inferior respiratory tract infection. The interpretation of the electrocardiogram led to a reconsideration of the medical history and the identification of anginal pain, resulting in referral to the cardiology department. The investigations carried out (biochemical tests, stress test, and coronary angiography) established the diagnosis of angina with non-obstructive coronary arteries (ANOCA). The uniqueness of the case lies in the association of this diagnosis with a combination of traditional cardiovascular risk factors (hypertension, dyslipidemia) and non-traditional factors (chronic inflammation, psychosocial stress). The average duration for establishing the diagnosis of ANOCA remains prolonged, contributing to the decrease in patient's quality of life. This case emphasizes the need for more efficient educational, diagnostic, and therapeutic strategies. It is essential to increase public awareness regarding the importance of addressing subtle symptoms that can be mistaken for the effects of aging and to reduce diagnostic delays in order to improve cardiovascular prognosis.

Key Words: microvascular angina, ANOCA, bacterial pneumonia, lipoprotein(a).

INTRODUCTION

Non-obstructive coronary artery disease (ANOCA) is a complex and often underdiagnosed clinical entity, encompassing subtypes such as microvascular angina and vasospastic angina under the same spectrum. Unlike obstructive coronary artery disease, characterized by significant atherosclerotic stenoses that are hemodynamically relevant, ANOCA involves mechanisms such as endothelial dysfunction or vasospasm, leading to myocardial ischemia despite the absence of atherosclerotic disease (Pepine, 2023). Young patients, particularly females without traditional risk factors, present with a higher incidence of this pathology (Anderson et al., 2019).

This condition is associated with significant morbidity and a reduction in the quality of life, primarily due to persistent and debilitating symptoms. Although the risk of major cardiovascular events was initially thought to be lower than in obstructive coronary artery disease, recent studies have shown otherwise (Skalidis et al., 2023) (Mehta et al., 2022). The reduction in functional flow reserve, which occurs in microvascular dysfunction, has been associated with diastolic dysfunction and a higher incidence of subsequent heart failure with preserved systolic function (Taqueti et al., 2018). Additionally, the predictability of angina-like pain onset is lower, occurring at rest as well as with exertion, and the symptoms are harder to control with current therapy (Smilowitz et al., 2023). All of these factors contribute to a vicious cycle, as patients reduce physical activity in order to avoid triggering symptoms. Over time, this may also increase the risk of progression of atherosclerotic disease, further reducing functional status (Shaw et al., 2006).

In a 2023 study by Martha Gulati et al., a major decline in the quality of life of these patients was noted using a questionnaire. Most of the respondents (40.4%) experienced symptoms for 1 to 5 years, and nearly half had symptoms for 1 to 10 years before receiving a diagnosis. A percentage of 77.8% had previously been informed that their symptoms were not cardiac in origin. Reported symptoms were varied, but 92.9% mentioned chest pain, pressure, or discomfort, and 80.6% reported dyspnea, which was classified as an angina equivalent (Gulati et al., 2023).

According to the European Society of Cardiology (ESC) guidelines published this year, once chronic coronary syndrome is suspected, ischemia requires objective documentation through stress or exercise tests, which may exacerbate the patient's

symptoms or show newly-emerged ECG changes suggestive of ischemia (Vrints et al., 2024). However, these tests cannot provide information about the mechanism of ischemia or quantify its severity, requiring further investigations such as CT coronary angiography or percutaneous transluminal coronary angiography. Although the recommendations are quite clear, literature evidence shows that there are numerous imperfections in this diagnostic algorithm. In a study of 96 women, the exercise test showed a sensitivity of 31% and a specificity of only 52% (Lewis et al. & National Heart, 2005) (Skelly et al., 2016).

The management of these patients differs from the traditional management of obstructive coronary artery disease. Treatment requires individualization, considering the wide range of mechanisms involved in the development of this syndrome. The relationship between psychological stress and the onset of angina in ANOCA requires better management of everyday stress, while physical exertion, dosed according to the level at which angina develops, is encouraged, although it may initially cause significant discomfort (Raija Tyni-Lenne et al., 2006). Regarding pharmacological therapy, the 2024 ESC guidelines are not as clear. Beta-blockers, calcium channel blockers, long-acting nitrates, and other antianginal medications such as ranolazine and trimetazidine are mentioned. The difficulty for controlling the symptoms requires adjusting medication according to the patient's needs (Vrints et al., 2024).

This case study presents the situation of a 45-year-old patient who initially presented with a lower respiratory tract infection, which led to a detailed cardiovascular evaluation and ultimately the diagnosis of ANOCA. The case highlights the importance of interdisciplinary collaboration and the need for increased awareness of ANOCA among clinicians, especially in patients with atypical presentations or unexplained ischemic changes on the electrocardiogram (ECG).

Another objective of this study is to highlight the low proportion of functional coronary tests performed currently in medical practice. The fact that the patient does not have an atherosclerotic stenosis should not automatically imply cessation of the path towards a correct diagnosis.

METHODOLOGY

Relevant keywords ["chronic coronary syndrome," "ANOCA," "microvascular angina," "vasospastic angina," "endothelial dysfunction," "atherosclerotic disease," "lipoprotein(a)"] were used to search through current literature from PubMed, Elsevier, and Google Scholar. Twenty-one articles were included from the approximately 200 reviewed. These articles, published in the last 10 years in English and Romanian, focused on meta-analyses, clinical studies, and practice guidelines.

The literature review involved a detailed comparison of the case specifics with previously reported data. A narrative approach was used to identify both similarities and discrepancies relevant to diagnosis and management.

The diagnosis was established according to the clinical presentation, ECG, biomarkers, exercise test, coronary angiography, and the evaluation of emerging factors [e.g., lipoprotein(a)].

In accordance with ethical standards, informed consent from the patient and approval of the study protocol by the ethics committee of "Dunărea de Jos" University of Galați were obtained.

Case presentation

A 45-year-old female patient presented to the emergency department of the Pneumoftiziology Hospital in Galați, complaining of fever, chills, initially dry, then productive cough, and fatigue. The symptoms had started insidiously about two weeks ago, with a progressive worsening in the last few days. After the investigations, an acute bacterial pneumonia diagnosis was established, and the patient received etiological and symptomatic treatment.

Among the investigations performed was an ECG, which showed repolarization changes in the anterior territory, suggestive of ischemia. Although the patient did not report any chest pain in the initial anamnesis, upon re-evaluation, she mentioned that she had started experiencing an anginal type of pain both at rest and during physical activity, beginning about a year ago. Prior to the onset of chest pain, the patient was physically active and regularly participated in mountain hiking. The onset of pain forced

her to significantly reduce her physical activity, which considerably impacted her quality of life.

Upon discharge, treatment with lipid-lowering agents, negative inotropes, and antiplatelets was initiated, following the 2024 European Chronic Coronary Syndrome Guidelines, and a cardiology examination was recommended for further investigations.

As per the pulmonologist's recommendation, the patient attended a cardiology consultation at the Military Emergency Hospital "Aristide Serfioti" in Galați. In addition to the anterior chest pain, the patient did not report other symptoms. During anamnesis, the patient revealed that her mother and sister both have cardiovascular conditions, although she was unsure about the specifics of their conditions. The physical examination showed an enlarged abdomen due to adipose tissue.

An ECG performed in the cardiology department (shown in Figure 1) still revealed ST-segment depression in the anterior leads. An echocardiogram was also performed, which showed a minor functional aortic regurgitation, without any wall motion abnormalities.

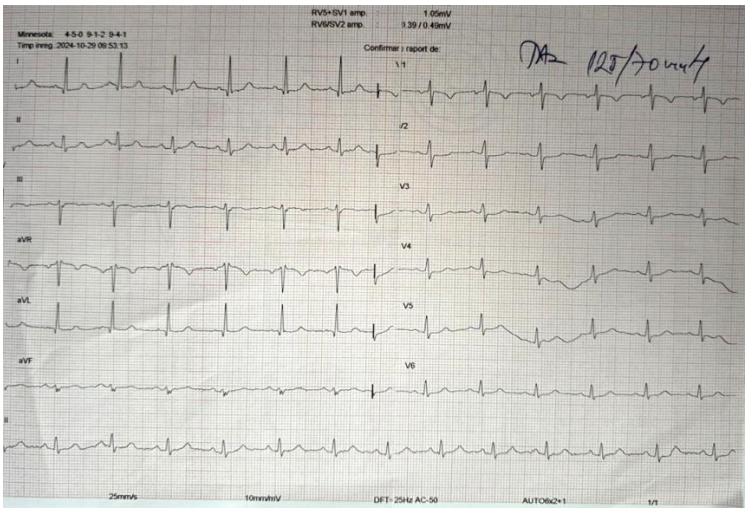
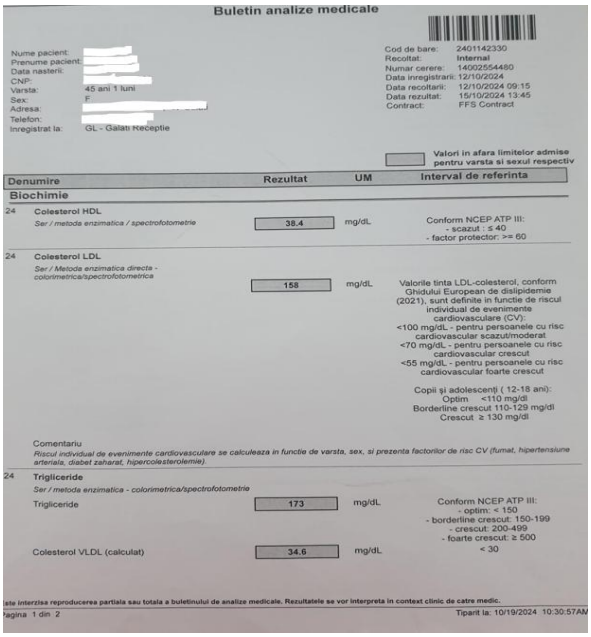


Figure 7: ECG at the presentation in cardiology department: sinus rhythm, 84/min, horizontal ST segment depression in leads V2-V4, artifacted trace.

Fortunately, the patient was also advised to measure LDL cholesterol, triglycerides, and lipoprotein(a) at baseline, before starting the treatment. The results are shown below in Figure 2 and Figure 3. These can be compared with the values from the tests performed on the day of the cardiology consultation, as presented in Figure 4. It is worth mentioning that the time interval between the two measurements was 17 days, during which the patient began treatment with atorvastatin 40 mg daily. A decrease

in LDL cholesterol was observed, from a value of 158 mg/dL to 84 mg/dL, and a decrease in triglycerides, from 173 mg/dL to 145 mg/dL, with an associated increase in HDL cholesterol from 38 mg/dL to 43 mg/dL. The lipoprotein(a) value was 30 mg/dL and was not measured afterward.



Buletin analize medicale

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Prenume pacient:
Data nasterii:
CNP:
Varsta: 45 ani 1 luni
Sex: F
Adresa:
Telefon:
Inregistrat la: GL - Galati Receptie

Cod de bare: 2401142330
Recoltat: Internal
Numar cerere: 14002554480
Data inregistrarii: 12/10/2024
Data recoltarii: 12/10/2024 09:15
Data rezultat: 15/10/2024 13:45
Contract: FFS Contract

Valori in afara limitelor admise pentru varsta si sexul respectiv

Denumire	Rezultat	UM	Interval de referinta
Biochimie			
24 Colesterol HDL *Ser / metoda enzimatica / spectrofotometrie*	38.4	mg/dL	Conform NCEP ATP III: - scazut : ≤ 40 - factor protector: >= 60
24 Colesterol LDL *Ser / Metoda enzimatica directa - colorimetrica/spectrofotometrica*	158	mg/dL	Valorile tinta LDL-colesterol, conform Ghidului European de dislipidemie (2021), sunt definite in functie de riscul individual de evenimente cardiovasculare (CV): <100 mg/dL - pentru persoanele cu risc cardiovascular scazut/moderat <70 mg/dL - pentru persoanele cu risc cardiovascular crescut <55 mg/dL - pentru persoanele cu risc cardiovascular foarte crescut Copii și adolescenți (12-18 ani): Optim <110 mg/dl Borderline crescut 110-129 mg/dl Crescut ≥ 130 mg/dl
Comentariu *Riscul individual de evenimente cardiovasculare se calculeaza in functie de varsta, sex, si prezenta factorilor de risc CV (fumat, hipertensiune arteriala, diabet zaharat, hipercolesterolemie).*			
24 Trigliceride *Ser / metoda enzimatica - colorimetrica/spectrofotometrie*			
Trigliceride	173	mg/dL	Conform NCEP ATP III: - optim: < 150 - borderline crescut: 150-199 - crescut: 200-499 - foarte crescut: ≥ 500
Colesterol VLDL (calculat)	34.6	mg/dL	< 30

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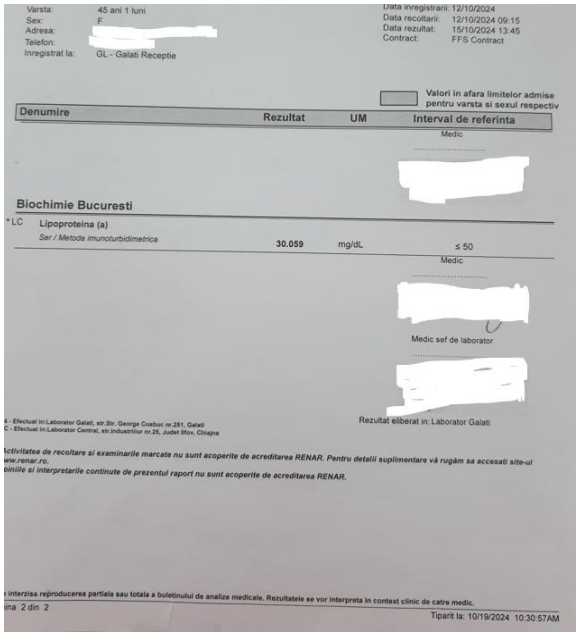
Pagina 1 din 2
Tiparit la: 10/19/2024 10:30:57AM

Figure 8: The blood tests recommended by the pulmonologist and performed by the patient immediately after discharge from the pulmonology department..



Varsta: 45 ani 1 luni
Sex: F
Adresa:
Telefon:
Inregistrat la: GL - Galati Receptie

Data inregistrarii: 12/10/2024
Data recoltarii: 12/10/2024 09:15
Data rezultat: 15/10/2024 13:45
Contract: FFS Contract

Valori in afara limitelor admise pentru varsta si sexul respectiv

Denumire	Rezultat	UM	Interval de referinta
			Medic
Biochimie Bucuresti			
* LC Lipoproteina (a) *Ser / Metoda imunoturbidimetrica*	30.059	mg/dL	≤ 50

Medic

Medic sef de laborator

Rezultat eliberat in: Laborator Galati

4 - Efectuat in:Laborator Galati, str.Str. George Cosbuc nr.251, Galati
C - Efectuat in:Laborator Central, str.Industriilor nr.25, Judet Ilfov, Chiajna

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Pagina 2 din 2
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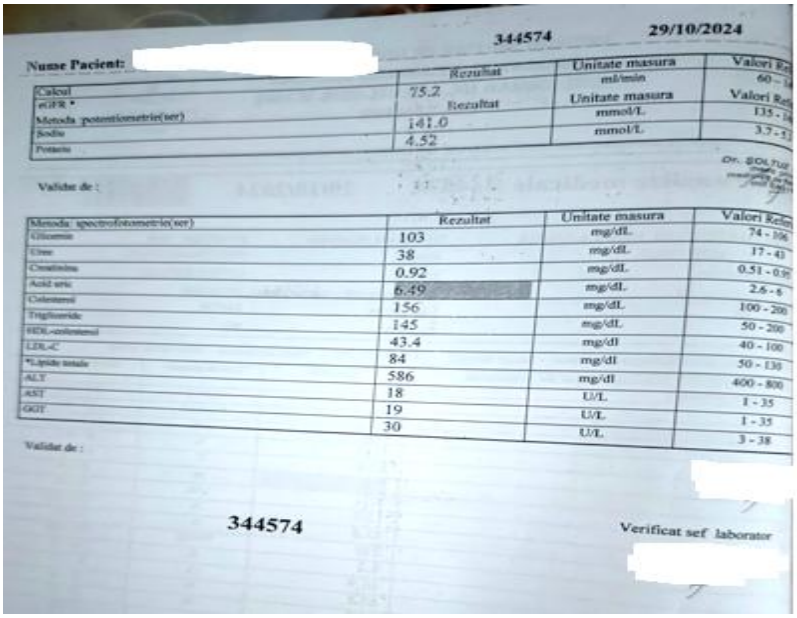
Figure 9: The blood tests recommended by the pulmonologist and performed by the patient immediately after discharge from the pulmonology department.



344574 29/10/2024

Nume Pacient: [redacted]

	Rezultat	Unitate masura	Valori Ref
Calcul eGFR *	75.2	ml/min	60 -
Metoda potentiometrie(ser)	Rezultat	Unitate masura	Valori Ref
Sodiu	141.0	mmol/L	135 -
Potasiu	4.52	mmol/L	3.5 -

Validat de :

Metoda: spectrofotometrie(ser)	Rezultat	Unitate masura	Valori Ref
Glicemie	103	mg/dL	74 - 106
Uree	38	mg/dL	17 - 43
Creatinina	0.92	mg/dL	0.51 - 0.95
Acid uric	6.49	mg/dL	2.6 - 6
Colesterol	156	mg/dL	100 - 200
Trigliceride	145	mg/dL	50 - 200
HDL-colesterol	43.4	mg/dl	40 - 100
LDL-C	84	mg/dl	50 - 130
*Lipide totale	586	mg/dl	400 - 800
ALT	18	U/L	1 - 35
AST	19	U/L	1 - 35
GGT	30	U/L	3 - 38

Validat de :

344574 Verificat sef laborator [redacted]

Figure 10: The blood tests at the time of presentation to the cardiology department, after approximately two weeks of treatment with atorvastatin 40 mg.

Given the symptoms and ECG changes, a treadmill exercise test was performed to evaluate the suspicion of coronary artery disease, which was found to be positive for ischemia (Figure 5 and Figure 6), with the onset of anterior chest pain, increased ST segment depression, and excessive blood pressure rise to approximately 192/69 mmHg, in the context of a normotensive individual. The exercise capacity, quantified using metabolic equivalents, revealed a value of 62% of the predicted capacity.

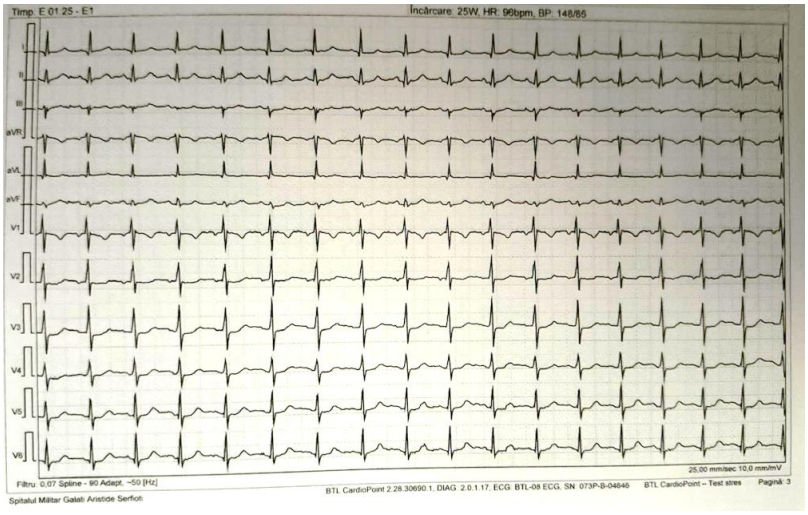


Figure 11: Exercise ECG trace, during exertion

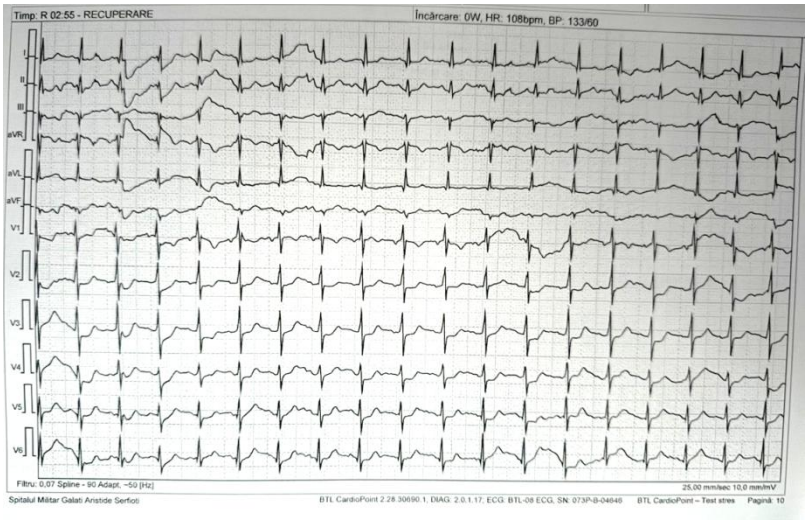


Figure 12: Exercise ECG during the recovery period: Increase of horizontal ST segment depression in the anterior leads.

Given the presence of high-risk criteria, coronary angiography was recommended to assess the patency of the coronary arteries. The angiography did not reveal any significant hemodynamically relevant lesions, and the epicardial coronary arteries were patent. Therefore, the final diagnosis was microvascular angina.

DISCUSSIONS

The severity of the pneumonia prompted the patient to seek care in a hospital setting—a measure that had likely been delayed, as had occurred over the past year since symptom onset, and as noted in other studies in the literature (Gulati et al., 2023). This case represents a fortunate example where a simple yet correct interpretation of an ECG ultimately led to the diagnosis of a condition with significant impact on the patient's quality of life.

Given the patient's symptoms, guideline-based treatment was initiated immediately after discharge from the pulmonology department, aiming to alleviate symptoms and reduce the risk of major cardiovascular events (Vrints et al., 2024). Initial investigations directed the diagnosis towards chronic coronary syndrome, a finding further supported by the exercise test. However, while the test indicated the presence of ischemia, it did not provide detailed information about its mechanism or the severity of the disease.

Although the patient did not belong to an older age group, the presence of genetic predisposition, symptomatology, and high cardiovascular risk criteria identified during

the exercise test justified the recommendation for coronary angiography. This was indicated both to assess coronary artery patency and for the possibility of percutaneous intervention with stent placement in the event of significant lesions.

The absence of hemodynamically significant coronary lesions required adjustments to the therapeutic plan, focusing on the management of reccurent symptoms. The time elapsed between the patient's discharge from the Pneumology Hospital and the cardiology consultation was approximately two weeks. During this period, although the patient was receiving nebivolol, a selective beta-blocker intended to reduce myocardial oxygen consumption, anginal pain persisted. In this context, initiating treatment with a non-dihydropyridine calcium channel blocker was recommended to alleviate anginal symptoms, alongside lipid-lowering therapy to reduce long-term cardiovascular risk (Vrints et al., 2024).

ANOCA, as emphasized in the introduction, is a spectrum rather than a standalone disease. Improving treatment success rates necessitates additional testing during coronary angiography, such as fractional flow reserve (FFR), coronary flow reserve (CFR), and optical coherence tomography (OCT) (Lee et al., 2022). These tests refine the diagnosis by providing insights into the pathophysiological mechanism and thus enable tailored medication adjustments. However, the procedure's duration significantly increases, and these features are not available in all interventional cardiology centers. In a study conducted by Sarena La et al. from January 2012 to December 2018, 7,555 patients suspected of angina pectoris underwent elective coronary angiography. The study revealed that an exceptionally low proportion (6%) of ANOCA patients underwent functional angiography, despite evidence of myocardial ischemia and patent coronary arteries. Over 90% of the patients in this cohort thus received empirical treatment without verifying its applicability to individual pathophysiological characteristics. Unsurprisingly, approximately one-third of the treated patients in the study continued to report frequent anginal chest pain (La et al., 2023).

Although the patient's coronary arteries were patent, baseline blood tests revealed dyslipidemia and hypertriglyceridemia. These abnormalities, correlated with an overweight status (BMI = 26.8 kg/m^2), indicate an early metabolic syndrome, which

is associated with a markedly elevated cardiovascular risk (Lemieux et al., 2020).

Moreover, the lipoprotein (a) level of 30 mg/dL, while within the laboratory reference range, has been shown in recent studies to be associated with increased mortality independently of other risk factors (Vinci et al., 2023; Iannuzzo et al., 2021). It has been demonstrated that this level is genetically inherited, conferring elevated cardiovascular risk, and the patient reported a family history of cardiovascular conditions in her sister and mother, although the exact pathologies could not be specified (Duarte Lau F et al., 2022).

The uniqueness of this case lies in the association of ANOCA with traditional cardiovascular risk factors such as dyslipidemia, hypertriglyceridemia, and hyperuricemia, alongside more recently studied factors like lipoprotein (a).

Ischemia in ANOCA can act synergistically with potential atherosclerotic stenoses, amplifying the severity of ischemia (Dimitriadis et al., 2024). Given that atherosclerosis is an inevitable consequence of aging, reducing cardiovascular risk through pharmacological interventions and lifestyle modifications becomes essential, especially in the presence of ANOCA. The patient's young age is a presumed advantage, as she is currently free from the consequences of atherosclerotic disease, as demonstrated by the coronary angiography. However, without timely medical attention, necessary interventions would not have been implemented, leading to progressive worsening of the symptoms and progression of the disease in the coming years.

CONCLUSIONS

To improve the management of patients with ANOCA, measures are needed from both the patient and specialist perspectives. For patients, it is essential to undergo regular medical check-ups, avoiding visits to the doctor only in cases of acute conditions or when the disease has reached an advanced stage. For specialists, it is crucial to conduct dedicated studies to better understand the mechanisms of ANOCA and implement strategies that facilitate the performance of necessary tests for an accurate diagnosis. This would allow for the prescription of targeted treatment, increasing the chances of therapeutic success, reducing hospitalisations, and improving patient's quality of life. Furthermore, this approach would contribute to lowering healthcare

system costs, thus being more economically beneficial compared to the current empirical treatments.

Lipoprotein (a) remains an insufficiently understood topic. While most existing studies explore its relationship with obstructive coronary artery disease, the possibility of an association with ANOCA should not be overlooked, requiring further investigation.

In conclusion, a sudden decrease in exercise tolerance in a physically active, previously asymptomatic patient, associated with the onset of new chest pain, should not be simply attributed to the aging process. Such symptoms should be thoroughly investigated to rule out a cardiovascular condition like ANOCA, which could benefit from early diagnosis and treatment.

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MUSCLE STRETCH AND NEURAL COORDINATION IN SHOTOKAN KARATE: INSIGHTS FROM A THEORETICAL APPROACH

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Abstract

The education of flexibility inscribed in this pattern of logic implies the identification of the reporting element for establishing the rhythm or algorithm at the point zero of the process, the investigation of the initial parameters at the first point, and the establishment of a limit of evolution that can be framed within a predefined time unit at the second point. As with any intervention involving changes in biological parameters of the human body, flexibility training must, at ground zero, be related to the natural limits of the biosystem represented by unconditioned reflexes. In this case, the unconditioned reflex that regulates the process of nerve-muscle communication and vice versa is the muscle stretch or myotatic reflex, whose physiological role is to maintain muscle tone, regulate balance and thus prevent potential injuries caused by sudden or forceful muscle stretching.

Key-words: muscle stretch, flexibility, Shotokan Karate.

INTRODUCTION

The stretch reflex regulates the degree of elongation of muscle fibres, allowing a balanced muscle tone between agonist and antagonist muscles. Any natural movement of the body triggers an elongation of the muscle fibres of the muscle group on the opposite side. For example, if an individual bends forward, the fibres of the leg muscles will lengthen, triggering the equivalent contraction of the stretching effect. If a neuromuscular spindle is elongated suddenly or forcefully, it triggers the inverse myotatic reflex, whose physiological role is to prevent muscle fibres and tendons from tearing. In this situation, instead of causing a muscle contraction, stretching induces the opposite state, i.e., relaxation, avoiding loading the muscles beyond their state of

resistance. In conclusion, the basic logical scheme or the pattern of any flexibility training algorithm lies between the functional limits of the body on the two axes of expression of the myotatic reflex: the impulse that stimulates stretching followed by contraction and stretching followed by relaxation.

The methodological parameters theoretically predefined by the investigations carried out in the biological, medical and sports fields are based on these limits imposed by the unconditioned reflex interpreted in the direction of its conditioning and represent the guiding axes of any attempt at programming.

Stretching is the field that is now internationally recognised as a representative of how it has differentiated, defined and developed the possibilities of stretching movements involving muscles, joints and the nervous system, which can lead to flexibility training and increased range of movement.

METHODOLOGY

The theoretical approach in this study was structured to analyse the interplay between muscle stretch and nerve-muscle communication, framed within the context of Shotokan Karate practice. We conducted a comprehensive review of existing scientific literature related to muscle stretch, nerve-muscle communication, and their interdependent processes.

RESULTS

Stretching, somatics and biofeedback

Stretching has been recorded as the status quo during research to identify procedural approaches to restore flexibility and elasticity of the skeletal and muscular systems by Thomas Hanna as well, a philosophy professor, neurologist and movement theorist who has invented the term *somatics*. Hanna's research, carried out in the informational context of the 60s and 70s of the past century, is now widely supported by both neurological and physiological arguments. The researcher's hypothesis,

following neurological studies, was that all life experiences lead to physical patterns in the body that may or may not support the maintenance of somatic balance, depending on the limitations they impose.

Hanna is also the author of the sensorimotor amnesia and sensorimotor awareness concepts. He believes that life routines that generate physical or behavioural patterns have the negative effect of sensory-motor amnesia, which essentially involves changes in self-perception, which can be translated by the inability of people to project themselves in their environment through the lens of natural limits. In other words, daily habits force the nervous system to build synaptic networks that can be perceived as structural limits of the body, although their nature is purely functional, the nervous system being capable of building new synapses continuously and constantly throughout life.

By being connected to the environment, the sensory-motor system is constantly reacting to external pressures through the activity of specific muscle reflexes. Subject to the effect of repetition, they cause conditioned muscle contractions which in turn cause joint and muscle contractions, which limit the body's natural movements. This state of dysregulation of the neuro-muscular control function, which consists in the diminution or lack of voluntary control of certain natural movements, has been named sensory-motor amnesia by Hanna, while also adding that it affects the self-image, the image of one's own emotions and capabilities: "Sense-motor amnesia is a state that occurs universally in the human species as a predictable result of long-term stress conditions. Constant repetitions of stress stimuli cause loss of volitional awareness of certain areas of the body musculature, usually predominantly those in the area of the centre of gravity, such as, for example, the musculature of the junction of the thoracic cage and pelvis musculature" (Hanna, "*What is somatics?"*, 1986, pp. 349,350). The return to the initial state takes into account the identification of the functions of neuro-muscular control, and the author of the study reached the zero point of the cause-effect relationship, the pandiculation, considering that the exit from the vicious circle or feedback loop closed by the sensory-motor amnesia can be made by sensory-motor awareness of the function of the pandiculation, to which he finds technical correspondences, creating a method that was the basis for the establishment of the

Novato Institute for Somatic Research and Training: "Hanna Somatic Education uses a specialized technique called pandiculation to reset muscle length and improve coordination" (https://hannasomatics.com/about_somatics/history_and_founder/).

Hanna's method is essentially based on the principle of biofeedback discovered by physician Edmund Jakobson in 1921. Through his studies and microvolt measurements, he demonstrated that the mind communicates with the body, and the body communicates with the mind through electrochemical nerve inputs. He also observed that muscle relaxation causes the mind to relax, and that muscles are involved in the thinking process, with thoughts generating muscle contractions or relaxations. The context of the 1920s was favourable to the scientific confirmation of these theories thanks to the emergence of electrophysiological instruments (in 1924 Hans Berger invented the electroencephalogram, the first form of brain electricity measurement), encouraging Jakobson to create a device that could measure the smallest electrical action potentials in fibres or nerves. Thus, the neuro-voltmeter was created, demonstrating that the mind works both centrally and peripherally. Nowadays, as a result of investment in neuroscience (a field of knowledge also generated by Jakobson's discoveries), devices that electromagnetically measure joints, muscles, the heart, the eyes, etc. have been developed. Wanting the results of his research to reach the general public, Edmund Jakobson published the book *You must relax* in 1934, which is today considered the main source of inspiration for all fitness and Pilates programmers who seek scientific explanations, avoiding correlations with yoga or karate, which are considered closer to Eastern than Western culture.

Thomas Hanna, however, does not fructify information from the previously mentioned fields of knowledge. His interdisciplinary specialisations (theology, philosophy, neurology) and his relationship experience with Moshé Pinchas Feldenkrais led to the creation of a perspective that in contemporary terminology, could be called 3D or even 5D if we integrate Feldenkrais' knowledge in the field of physics (he was a physicist, student of Marie Curie and assistant of Jean Frédéric Joliot-Curie) and in the field of martial arts (he practised martial arts, having as mentors Jigaro-Kano and Mikinosuke Kawaishi). In his works, *Somatics: Reawakening the Mind's Control of Movement, Flexibility, And Health* (1988) and *What is Somatics?* (1995), Thomas

Hanna argues his hypotheses interdisciplinary by creating an angle of information reception that places the reader in a subjective relationship with their own body from the perspectives of the first person and the second person and in objective relation from the perspective of the third person.

By circumscribing the possibility of activating the sensory-motor awareness of the soma domain, which is, in Hanna's view ‘‘the body as perceived from within by the first person" (Hanna, 1986), believing therefore that through learning somatics, man can regain full control over neuro-muscular functions, which in the translation of the flexibility education system would imply total freedom of relationship with the natural limits of the flexibility of the human body. Thus, through voluntary and conscious training, new synaptic networks can be built, which will restore the body's natural flexibility, inhibited over time due to the repetitive behaviours that created sensorimotor amnesia.

Correlating the arguments that substantiate the relationship between the involuntary reflex of stretching the body, pandiculation, and stretching, with those that demonstrate the possibility of returning to the natural effects of the activation of pandiculation through sensory-motor awareness and with those that demonstrate how neurons in the motor area of the brain act, we have identified the possibility of creating a new method of educating flexibility through the basic functions of Shotokan Karate to which we have associated, at the instrumental level, the Dartfish 360 S and Mobee Med applications which trigger, at the theoretical level, regardless of the degree of motivation or reflexive capacity of the practitioners, the first-person perspective.

Stretching, the nervous system and conscious control

Our vision affirms the existence of an anatomophysiological framework that confirms two possibilities in a state of major convergence:

- the possibility of improving flexibility from a technical point of view by applying scientific principles in a program that has the effect of increasing sports performance;
- the possibility of remodelling the body along the lines of the natural flexibility specific to human nature.

These two objectives can be achieved while respecting both the anatomophysiological characteristics, which, as mentioned above, define the relationship between the nervous and muscular systems and the order in which the specific balance of communication between the two systems implies. Of the researchers concerned with understanding and defining communication between the nervous and muscular systems, Moshe Feldenkrais is the one who has emphasized their importance of order. With a dual perspective as a karate practitioner and physical scientist, he emphasised the primacy of the nervous system in shaping the body: "Movements mean nothing. I'm not looking for flexibility of the body, but of the nervous system. What I seek is to restore human dignity in each person" (Verin, 1978). This level of awareness has made it possible to understand the long-term effects of both the dominantly passive or withdrawn behaviours of people living in a stressful, hostile environment and the dominantly active behaviours of people living in a favourable environment, conducive to freedom of expression and affirmation.

Thus, Feldenkrais observed the existence of two bodily patterns determined by these two forms of pressure of the living environment and the possibility of body remodelling by redefining the mental attitude of individuals towards the environment. His method is also based on static or dynamic voluntary muscular contractions, known today as stretching, accompanied by breathing exercises and the realisation that most bodily dysfunctions are the consequences of the posture adopted as an unassumed reaction to the stress of the living environment. In other words, Feldenkrais' research brings the idea of the relationship between the quality of an athlete's lifestyle and his or her bodily capabilities into the system of data supporting the effects of stretching, forcing us to integrate informational and behavioural elements that involve the creation of these mental links for each practitioner into the flexibility improvement program.

This learning method is based on the importance of self-image, the plasticity of the nervous system and its learning faculties.

Feldenkrais talks about organic learning, i.e. the relationship between sensory-motor experiences and the development and growth of neural connection networks. For him, movement is the best mirror of an individual's life, the best index of nervous system activity, as well as a pretext for self-awareness. This way of looking at the body and

mind as a whole, movement being the mirror of the functioning of the central nervous system, allowed the method to reconnect the structures of the human being as a whole to be functionally well integrated, i.e. capable of individual choices/decisions" (Carmen Șerbănescu, *Metoda Feldenkrais*, 2015, p. 22).

Once again, surprisingly, the empirical research that Shotokan Karate has enjoyed so far proves that the system was created on fundamental principles, as we can find sufficient control tools on this segment within it. Dignity and self-respect, vigilance and focus on the attitude that demonstrates the awareness of action as a form of expression in both attack and retreat are fundamental axes both in training and in the evaluation of a karateka that athletes learn as behavioural principles, referring to them as standards and criteria for competitive credit. Therefore, the scientific data on the interactions between the osteo-muscular, nervous and self-awareness planes have a technical and procedural counterpart within the Shotokan Karate system and encourage us to believe that stretching supported by breath control and control of attitude and posture will lead to improved flexibility to the point of conscious control of joint amplitude.

Types of stretching

Neuromuscular facilitation

Passive neuromuscular facilitation was developed by Herman Kabat, a neurophysiologist, in the late 1940s. Using the model of the neuromuscular activity described by Sir Charles Sherrington, he laid the foundations for treatment using neuroproprioceptive facilitation techniques. The patients for whom this type of treatment was intended were those suffering from post-polio syndrome, who until then had been treated one movement, one joint and one muscle at a time. Kabat's formula is his own: "Every human being, and therefore also the patient, has latent motor possibilities, which can be stimulated and activated by appropriate facilitations." (https://xdocs.ro/doc/rolul-tehnicilor-de-facilitare-neuroproprioceptive-n-recuperarea-fizica-loywmxer6m83). Today, the PNF has been taken up by all medical and sports fields involving body remodelling in this segment.

Depending on the objectives pursued, the authors of movement programs for the development of flexibility, use the information whose bases were created and developed in the Kabat-Kaiser Institute. An important aspect of the method is the possibility of creating and organizing movements according to the nature of the stimuli:

- proprioceptive stimuli;
- exteroceptive stimuli;
- telereceptive stimuli.

Stimulation may target a single group of stimuli or a combination of several. Exercises involving touch achieve proprioceptive and exteroceptive stimuli. Voice commands and movement patterns activate telereceptive stimuli, such as hearing and vision.

Depending on the nature of the stimuli, programmers may use facilitators or method-specific manoeuvres aimed at amplifying or reducing the intensity of the feedback:

- Proprioceptive elements: stretching, resistance, telescoping or traction;
- Exteroceptive elements: light temperature tapping or paravertebral tapping;
- Common proprioceptive and exteroceptive elements: manual contact, pressure on long tendons;
- Telereceptive and interoceptive elements: visual patterns, auditory commands, carotid sinus stimulation.

The PNF method provides practitioners with movement patterns that emphasize the application of maximum resistance throughout the entire range of motion. The authors of the method have concluded that the best types of movement are diagonal and spiral movements because they allow maximum elongation of the muscles so that the myotatic reflex is applied to the entire range of motion. The method-specific movement patterns follow the following logical patterns:

1. The initial stimulation of the strong muscles (this allows the nervous influx to radiate to the weak muscles and to generate a positive perception from the practitioner's psychological point of view);
2. The realization of the sequence of active-free, active-assisted, active with resistance or passive movements;

3. The choice of movement positions that allow the patterns to be performed easily and without force.

The ballistic stretch

The medical dictionary defines ballistic stretching as: "Stretching or warm-up that uses the momentum of a moving body or limb in an attempt to force it beyond its normal range of motion by jumping into or out of the stretched position, using the stretched muscles as a spring to get out of the stretched position; ballistic stretching is not considered helpful and can lead to injury; it does not allow the muscles to adapt and relax into the stretched position, but rather can cause them to tighten by repeatedly activating the stretch reflex." (https://medical-dictionary.thefreedictionary.com/ballistic+stretching). The medical definition creates the limiting framework from the point of view of ensuring the health of practitioners, the margin of risk being conditioned both by the particularities of each sport itself and by their anatomophysiological and volitional particularities. Integration into a martial arts program, including Shotokan Karate, involves validating the practitioner's availability on all three levels to perform the ballistic movements specific to the field. The program's author is obliged to take into account this double hypothesis of relationship with the practitioner when designing the program:

- biologically predefined limits in a picture of possible negative effects normalized to the general coordinates of the human body;
- the individual limits of practitioners monitored by continuously recording their evolution with the help of classical (communication and data recording on a routine basis) and modern (logs provided by the archive of chosen technologies for recording progress) testing tools.

The positive effects of ballistic stretching recommend this method particularly to practitioners of sports that involve complex jumping, including martial arts. The fact that athletes' proprioception involves the imagistic integration of movements that require the specific effort of ballistic stretching reduces the risk point, since the method is included in the states of progress that its advantages imply, namely:

- more stretching of the muscles than in other standard stretching techniques;
- improved tendon elasticity;
- reduced Achilles' tendon stiffness;
- improved blood circulation;
- reduced possibility of muscle soreness.

Dynamic stretching

Dynamic stretching is a method similar to ballistic stretching, the difference being in the way the exercises are performed. The movements involve moving the limbs and trunk in a controlled and slow manner, therefore without resorting to the force and sprints typical of ballistic stretching. In this way, it is possible to perform the exercise within the range of motion of the joint. The movements defined by dynamic stretching are performed by actions of the limbs in a certain direction in a controlled and slow manner, aiming at the gradual exploitation of the entire amplitude of the joint. The speed of the movements is controlled so that the effect on the myotatic reflex causes the muscle to react by contracting rather than relaxing.

Dynamic stretching is repetitive and progressive in nature. Traditional practice recommends dynamic stretching in the stage of preparation for physical activity, as it has the following effects:

- helps increase body temperature;
- increases the transmission speed of nerve signals;
- stimulates the muscles and the enzyme cycle;
- accelerates energy production.

The central axis of dynamic stretching manifestation is the relationship between agonist and antagonist muscles. The neuro mechanisms involved in the relationship between these two types of muscles was conceptualized by Sir Charles Sherrington (1857 - 1956), considered the philosopher of the nervous system. Active stretching movements apply the following neuromechanisms:

- Reciprocal inhibition that manifests itself through the sequence: while the agonist muscles contract, the antagonist muscles relax, their contraction being inhibited to create the balance necessary to maintain the health of the muscles;
- Muscle spindles that are manifested by the ability of the sensory nerve endings in the muscle to detect the change in the length of the muscle and its rate of change.

Static stretching

Static stretching is a method that involves lengthening the muscles with the application of a low force and for a long time (on average, 30 seconds). Static stretching has a relaxing and lengthening effect on muscles, which increases range of motion, decreases muscle and tendon stiffness, and also reduces the risk of acute muscle injuries. It is a slow, controlled movement with an emphasis on postural awareness and body alignment. It is suitable for all types of sports or physical activities in general.
Traditional practice recommends performing static stretching exercises before actual training or sports competition to improve muscle performance and minimize the risk of injury, and describes the method as having a low risk of injury. However, more recent research does not maintain the same perspective, listing among the negative effects, roughly the same long-term risks that most exercises that involve constant pressure on the body's conditioned reflexes. Among them, according to a study presented by physio-pedia.com, one can find:

- The decrease in the viscoelastic behaviour of muscles and tendons only in the short term, without long-term effect;
- the decrease in the excitability of the motor neuron through the inhibitory effect in the Golgi tendon organ and through the activation of the recurrent Renshaw loop (recurrent inhibition);
- the decrease in motor unit activity;
- the decrease in the activity of the muscle spindles, which results in a decrease in the activity of the myotatic reflex. (https://www.physio-pedia.com/Impact_of_Static_Stretching_on_Performance#cite_note-:0-1)

CONCLUSIONS

The differences between the particularities of these methods, as noted from their description, do not concern the principles of operation and interaction of the bone, muscle and nervous systems, but the extent to which the use of these principles in a rhythm, a cadence, with a speed or a force of certain types can induce the expected effect. Since the effects are aimed both at increasing performance and maintaining health or returning to health, the methodology of stretching or flexibility is approached theoretically or practically in various fields of knowledge: physiotherapy, neurology, biomechanics, most sports fields, etc. The informational level generated by technology forces any study author of this topic to face the vastness of research results in all these fields where flexibility is defined and interpreted in relation to the criterion of interest regarding the transformation or modification expected or already produced in the basic system of the field. Thus, the palette of accessible elements in order to test effects in relation to Shotokan Karate is considerable, concepts such as: pre-contraction stretching, post-facilitation stretching, biomechanical model, sensory model, neural model, passive-static stretching, static-active stretching, stretching isometric, offering various perspectives of how the human body manifests itself during the process of muscle contraction-relaxation under mechanical or mental pressure.

We believe that the principle that is imposed in the methodological approach of flexibility in order to make a program is the creation of personalized algorithms with double valence: the anatomical-physiological and psychological particularities of the practitioners and the temporal and objective particularities of the program.

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WHEN SPORTS BECOME HARMFUL-A CASE STUDY

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Abstract

This study presents the case of a 27-year-old man who presented with progressive fatigue and discomfort in both hands, symptoms that led to the diagnosis of bilateral carpal tunnel syndrome. Exclusion of secondary causes and the absence of professional exposure to repetitive movements allowed for attributing the etiology to mechanical stress, resulting from a prolonged history of joint overuse associated with weightlifting. The aim of this study is to highlight a possible connection between excessive engagement in sports activities and the development of carpal tunnel syndrome. In recent years, awareness of the importance of physical activity has significantly increased, which is a positive aspect; however, even a beneficial activity like sports must be balanced, as excess can have repercussions.

Keywords: sports, carpal tunnel syndrome, tennis elbow, overuse, mechanical stress, Brazilian jiu-jitsu.

INTRODUCTION

Among the most frequently encountered neuropathies worldwide, carpal tunnel syndrome is caused by compression of the median nerve at the level of the carpal tunnel, an anatomical structure through which the nerve passes to the distal innervation territory. The symptoms can range from pain to paresthesia and even functional impairment. The symptoms are usually triggered by sustained or repetitive hand activities, such as holding a book or typing, and are alleviated by rest, shaking hands, placing them under a stream of cold water, or using a brace. In the absence of treatment, paresthesia may become constant, followed by the development of muscle weakness and atrophy of the muscles in the thenar eminence, innervated by the median nerve. Modifying activities involving the use of hands may lead to symptom improvement or remission, but there is a risk of future recurrence (Padua L, 2016) (MH., 2017).The most common cause of carpal tunnel syndrome is long-term overuse of the wrist through repetitive movements. Acute cases have also been documented, in which median nerve compression occurs due to trauma (Gillig JD, 2016). However, it can also occur secondarily, serving as an early indicator of systemic conditions such as diabetes, amyloidosis, hypothyroidism, or rheumatoid arthritis, among others, though much less frequently. Most commonly, it occurs unilaterally in individuals with professional exposure (Osiak K, 2021).

The diagnosis is usually suspected based on the medical history and clinical examination, and is confirmed through electromyography (EMG), which enables the assessment of the impulse conduction velocity along the median nerve (Sonoo M, 2018) (MH., 2017).

Treatment options include ultrasound therapy, laser therapy, and electromagnetic fields. These are performed as part of a rehabilitation program alongside re-education of the patient regarding wrist engagement in daily movements and physical therapy. In advanced cases that have not been fully treated by the aforementioned methods, surgery for median nerve decompression may be performed (Gräf JK, 2022) (Wipperman J, 2006) (Kim PT, 2014). In the Journal of Sports and Orthopedic Physiotherapy, it was noted in 2019 that more than half of patients diagnosed and treated with conservative methods eventually undergo surgery within the first year after diagnosis (Therapy,

2019). However, in younger patients, the outcomes of the intervention are more unpredictable (HOBBY JL, 2005).

The impact of carpal tunnel syndrome on the patient's life is significant, affecting both professional activities and daily life. This condition may require substantial adjustments to the daily routine, and in severe cases, it may even require a career change (Padua L, 2023) (Çupi B, 2023) (E. Polykandriotis, 2007).

METHODOLOGY

This study was conducted following the informed consent of the patient and the evaluation of the study protocol by the Ethics Committee of "Dunărea de Jos" University in Galați. Terms such as "carpal tunnel syndrome," "lateral epicondylitis," and "peripheral nerve injuries in sports" were used to analyze current evidence and knowledge in the specialized literature. After presenting the clinical case, a comparison was made between its particularities and the results highlighted in available studies to identify clinically and scientifically relevant similarities and differences. Figure 1 illustrates an anatomical image depicting the compression of the median nerve in carpal tunnel syndrome.

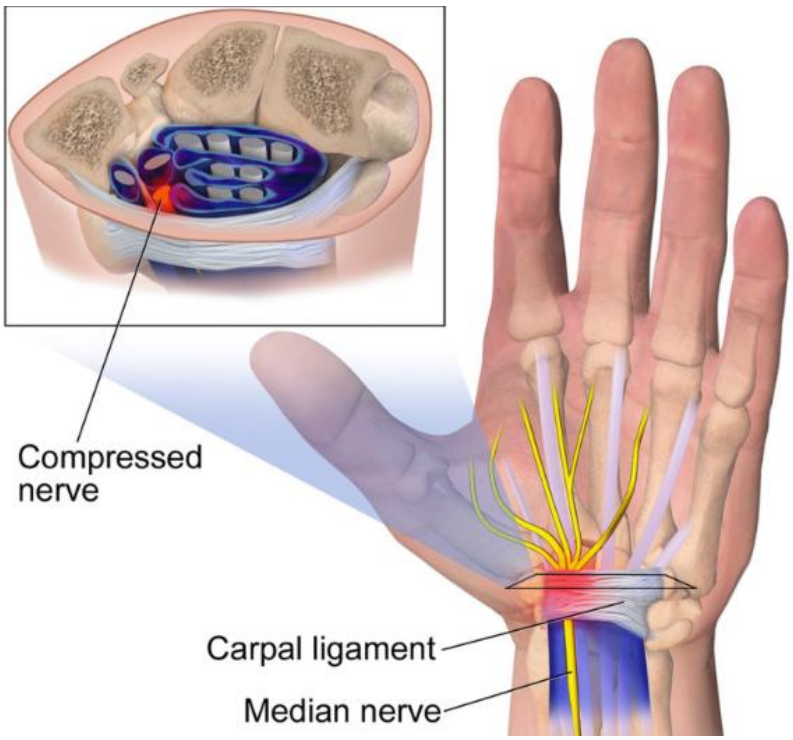


Figure 13 Median nerve compression. (10.7759/cureus.27053) (Joshi, 2022)

Case presentation

A 27-year-old male patient presents with a sensation of fatigue and discomfort in his right hand while writing. The symptoms also occur in the left hand when typing on a laptop. The onset was insidious, occurring approximately 3 months ago, with a gradual decrease in the threshold for symptom appearance. In the family history, there is a history of breast neoplasm in the maternal grandmother and renal neoplasm in the paternal grandmother, both treated and in remission for over 15 years. In the personal medical history, the patient underwent an appendectomy at the age of 20. The patient states that he is a doctor and has no professional exposure to repetitive movements. He also denies tobacco and alcohol use and practices various sports, with bodybuilding being the most consistent for approximately 15 years and Brazilian jiu-jitsu for about 5 years.

On clinical examination, calluses are noted on the palmar surfaces of the metacarpophalangeal joints bilaterally alongside hypertrophy of the right thenar eminence, with normal mobility and no traumatic marks (Figure 2). During the Phalen test, the patient reports the onset of bilateral paresthesias.

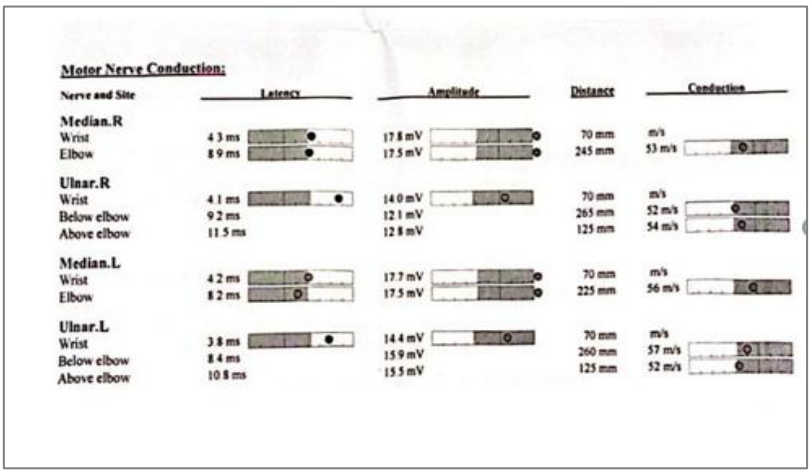
Figure 14 Clinical examination (from personal archive)

A musculoskeletal ultrasound (EMS) was performed, which revealed an enlarged median nerve proximal to the flexor retinaculum on the right hand, for which electromyography (EMG) was recommended. Additionally, during the ultrasound evaluation of the hand and finger extensor tendons, edema, microcalcifications, and microvascularity were noted upon Power Doppler interrogation, particularly at the

insertion sites on the lateral epicondyle, suggesting a diagnosis of lateral epicondylitis (Figure 3). The same changes were observed in the left arm, but to a lesser extent.

Figure 15 Musculoskeletal ultrasound. Edema at the insertion of the extensor muscles of the hand and fingers. (From personal archive)

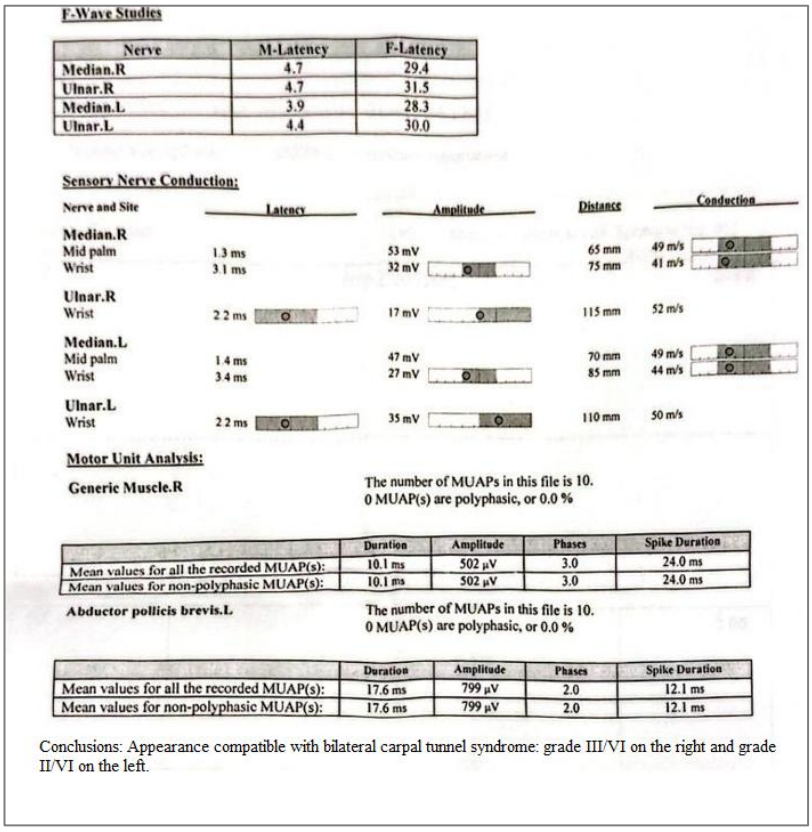
Given the reproducibility of the paresthesias during the clinical examination and the findings from the EMS, an EMG was recommended, which led to the diagnosis of bilateral carpal tunnel syndrome, grade III/V on the right hand and grade II/V on the left hand (Figures 4 and 5).



Motor Nerve Conduction:

Nerve and Site	Latency	Amplitude	Distance	Conduction
Median.R				
Wrist	4.3 ms	17.8 mV	70 mm	m/s
Elbow	8.9 ms	17.5 mV	245 mm	53 m/s
Ulnar.R				
Wrist	4.1 ms	14.0 mV	70 mm	m/s
Below elbow	9.2 ms	12.1 mV	265 mm	52 m/s
Above elbow	11.5 ms	12.8 mV	125 mm	54 m/s
Median.L				
Wrist	4.2 ms	17.7 mV	70 mm	m/s
Elbow	8.2 ms	17.5 mV	225 mm	56 m/s
Ulnar.L				
Wrist	3.8 ms	14.4 mV	70 mm	m/s
Below elbow	8.4 ms	15.9 mV	260 mm	57 m/s
Above elbow	10.8 ms	15.5 mV	125 mm	52 m/s

Figure 16 Electromyographic study page 1/2 (From personal archive)



F-Wave Studies

Nerve	M-Latency	F-Latency
Median.R	4.7	29.4
Ulnar.R	4.7	31.5
Median.L	3.9	28.3
Ulnar.L	4.4	30.0

Sensory Nerve Conduction:

Nerve and Site	Latency	Amplitude	Distance	Conduction
Median.R				
Mid palm	1.3 ms	53 mV	65 mm	49 m/s
Wrist	3.1 ms	32 mV	75 mm	41 m/s
Ulnar.R				
Wrist	2.2 ms	17 mV	115 mm	52 m/s
Median.L				
Mid palm	1.4 ms	47 mV	70 mm	49 m/s
Wrist	3.4 ms	27 mV	85 mm	44 m/s
Ulnar.L				
Wrist	2.2 ms	35 mV	110 mm	50 m/s

Motor Unit Analysis:

Generic Muscle.R

The number of MUAPs in this file is 10.
0 MUAP(s) are polyphasic, or 0.0 %

	Duration	Amplitude	Phases	Spike Duration
Mean values for all the recorded MUAP(s):	10.1 ms	502 µV	3.0	24.0 ms
Mean values for non-polyphasic MUAP(s):	10.1 ms	502 µV	3.0	24.0 ms

Abductor pollicis brevis.L

The number of MUAPs in this file is 10.
0 MUAP(s) are polyphasic, or 0.0 %

	Duration	Amplitude	Phases	Spike Duration
Mean values for all the recorded MUAP(s):	17.6 ms	799 µV	2.0	12.1 ms
Mean values for non-polyphasic MUAP(s):	17.6 ms	799 µV	2.0	12.1 ms

Conclusions: Appearance compatible with bilateral carpal tunnel syndrome: grade III/VI on the right and grade II/VI on the left.

Figure 17 Electromyographic study page 2/2 (From personal archive)

The patient had a recent set of blood tests performed in an outpatient setting, which did not show any pathological values. Additionally, the patient underwent an electrocardiogram (ECG) and a transthoracic echocardiogram, both of which were recommended following a presentation four months ago due to a lower respiratory tract infection. These tests also showed no modifications suggestive of a systemic disease that could present with bilateral carpal tunnel syndrome at onset. Figures 6, 7, and 8 present the following: the electrocardiogram showing sinus rhythm at 71/minute, a slight right QRS axis deviation, and incomplete right bundle branch block; the transthoracic echocardiogram in the parasternal long axis view; and the transthoracic echocardiogram in the parasternal long axis, with blood flow assessed through color Doppler examination. Figure 8 shows a slight functional mitral regurgitation jet, resulting from a mild mitral valve prolapse.

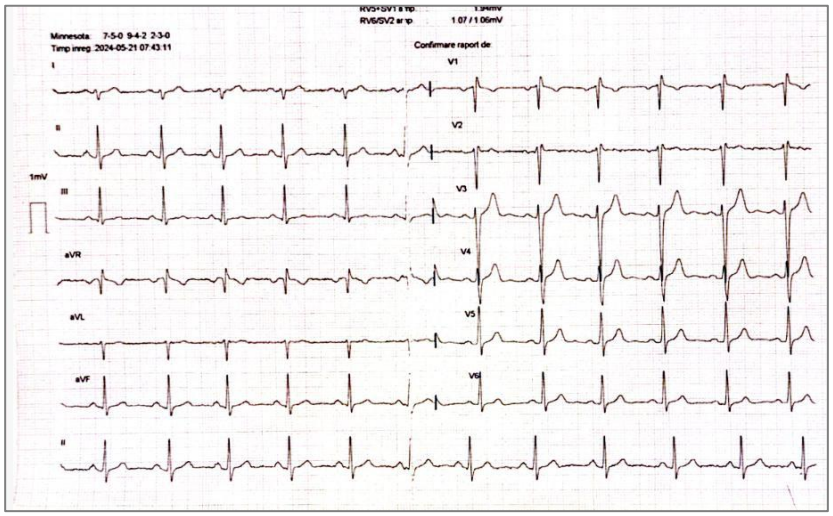


Figure 18 Electrocardiogram: Sinus rhythm, 71/min, mild right QRS axis deviation, incomplete right bundle branch block (From personal archive)

Figure 19 Transesophageal echocardiography, parasternal long axis view (From personal archive)

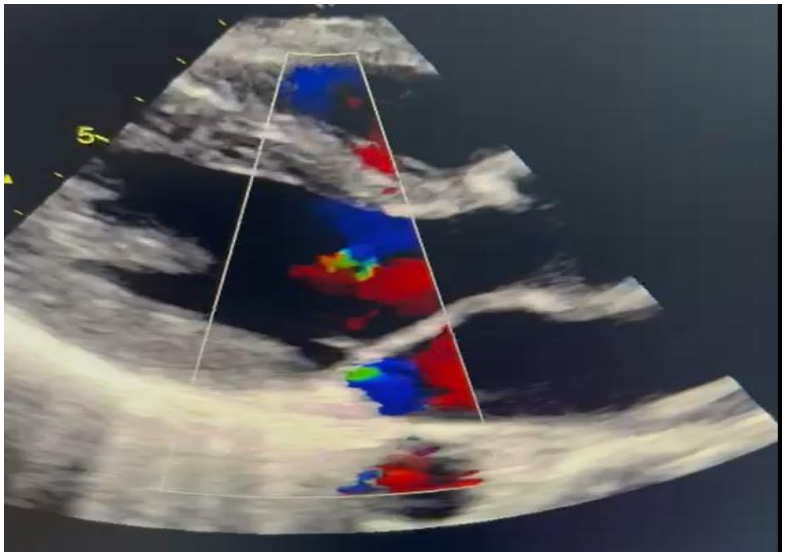


Figure 20 Transthoracic echocardiography, parasternal long axis, blood flow interrogation using color Doppler. An eccentric jet of mild functional mitral regurgitation is observed, caused by a slight mitral valve prolapse. (From personal archive)

DISCUSSIONS

The differential diagnoses considered included diabetes mellitus, amyloidosis, hypothyroidism, and repetitive strain injuries. Multiple sets of tests, conducted periodically in the outpatient setting, indicated the absence of hyperglycemia and thyroid hormone alterations, excluding diabetes and hypothyroidism. Amyloidosis was also ruled out based on the electrocardiogram and transthoracic echocardiogram performed about four months ago. Although further investigations, such as synovial biopsy, could be necessary to exclude conditions like amyloidosis, they were not indicated at present due to their invasive nature and the higher likelihood that the symptoms were related to intense physical activity. The clinical decision was thus oriented toward assessing and managing the most likely underlying cause (Bäcker HC, 2022). The only plausible etiology identified was repetitive mechanical stress. In the absence of professional exposure to risk factors, the history of intense sports training was considered the main contributing factor, especially given the associated diagnosis of lateral epicondylitis.

Bodybuilding and martial arts involve repetitive flexion-extension movements, particularly under load, which can increase pressure within the carpal tunnel. Chronic overuse can lead to hypertrophy of the muscles around the median nerve, contributing to symptom onset through compression. Specific characteristics related to both the type of training and the individual may influence the onset or progression of the syndrome.

A review by Mitchell et al. (2014) highlighted a significant prevalence of peripheral neuropathies among elite athletes, often underdiagnosed. The authors emphasized that symptoms are frequently attributed to other more common conditions, which contributes to delayed identification of neurological issues. Remarkably, neuropathic changes were detected using magnetic resonance imaging (MRI) even in subclinical stages, before the onset of overt clinical manifestations (Charles H. Mitchell, 2014). This underscores, on one hand, the importance of advanced screening among athletes for early diagnosis of these conditions and, on the other, that the prevalence of neuropathies may be even higher than estimated (Busche, 2008). The exact incidence of peripheral nerve injuries is not well known due to the lack of recent epidemiological studies (Tettenborn B, 2016).

An older study by Mauer UM, published in 1991, assessed 30 bodybuilders and noted a correlation between training duration and the onset of carpal tunnel syndrome induced by mechanical stress (Mauer UM, 1991). Even in athletes less expected to experience such conditions, like elite shooters, it appears that after six months of regular training, they develop peripheral nerve conduction disorders, including carpal tunnel syndrome (Rajczewski et al., 2023). These changes were attributed to a combination of recoil from the weapon and prolonged positions during shooting, highlighting the need for preventive measures, such as longer intervals between training sessions and the use of ergonomic equipment.

Studies comparing strength and mobility of the wrist between individuals with and without lateral epicondylitis have shown a significant reduction in the strength of extensor muscles and range of motion, along with decreased radial deviation of the hand (Kim, 2024) (Chourasia AO, 2012).

Although the history of physical activity was initially considered a beneficial factor, investigations gradually ruling out potential causes led to a detailed reassessment of the type and intensity of training. Upon further questioning, the patient admitted to overexerting himself during both weightlifting and Brazilian jiu-jitsu training.

The patient was educated regarding hand ergonomics, rest, and modification of training techniques and intensity. Additionally, a referral for Physical Medicine and Rehabilitation was made to initiate specialized treatment: ultrasound therapy, laser therapy, electromagnetic field therapy, and physiotherapy.

Given the moderate severity of the condition, median nerve decompression surgery was not indicated at this stage, although it could become necessary in the future without adequate recovery.

A notable feature of this case is the concomitant presence of bilateral epicondylitis, also known as "tennis elbow," a condition also caused by repetitive mechanical stress common to many sports activities (Ahmed AF, 2023) (Johns N, 2020). This further supports the hypothesis that the etiology of the patient's symptoms is linked to excessive physical training.

Although pain in the forearms was not one of the initial presenting complaints, upon more detailed history taking, the patient acknowledged experiencing pain,

although less bothersome compared to the fatigue felt at the wrist during activities. Moreover, the patient mentioned that forearm pain developed gradually, around the same time as symptoms in the wrist.

This raises questions about a potential link between epicondylitis and carpal tunnel syndrome, as well as the possibility that one condition may influence the onset or progression of the other. The localized edema at the insertion and course of the extensor muscles could, in theory, extend distally toward the carpal tunnel, generating compressive phenomena (Stephen S. Bao, 2016). Further studies are needed to investigate the potential significant association between these two pathologies, especially considering that they share common risk factors, such as repetitive mechanical overuse.

CONCLUSIONS

This case highlights the potential of high-intensity sports training in the early development of carpal tunnel syndrome, even in the absence of traditional risk factors. While physical activity is undertaken to maintain optimal health, it must be performed in a balanced manner, and the principle "the more, the better" does not always apply. This is especially relevant in the context of the significant increase in public interest in physical activity. Often, the general recommendation is to encourage movement, considering the prevalence of sedentary lifestyles. However, for individuals already engaging in non-competitive sports, it is essential to adopt a balanced approach to avoid tipping the scale toward negative effects. Sport is indeed beneficial, but educational programs should also be implemented to guide a calculated and balanced practice of it.

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THE STUDY ON THE MOTIVATION OF STUDENTS TO PLAY HANDBALL OR OTHER SPORTS ACTIVITIES

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Abstract

The purpose of this paper is to find out the reasons why students are attracted to play handball or other sports activity and the reasons that lead them to abandon these sports activities. The study was conducted on a sample of 60 students, 40 boys and 20 girls, aged between 13 and 14 years old. To begin with, I made a questionnaire that I applied to the group of students, in order to be able to observe their interest in practicing handball sports or in practicing other sports activities, and I followed the students' interests, the purpose and what motivates them to practice handball. Some students also practiced other sports such as: football, volleyball, basketball, handball and swimming. Students are attracted in a special way by the desire to belong to a group, by the desire for affirmation, by the desire to develop harmoniously from a physical and motor point of view, all of which are Pro arguments in order to practice the game of handball. If we look at the other side of giving up playing handball, it is due to the lack of knowledge of the benefits of this game on the development of each individual, the lack of intrinsic motivation, the lack of positive models, the lack of materials necessary for the development of these sports activities, the lack of promotion.

Key Words: children, sport, motivation, participation, handball.

INTRODUCTION

Recently, we have observed the need for students to participate in various sports activities and their awareness of the positive effects of playing handball. To reach this goal we need a mobilization from each student, with a little influence from the family that plays an important role in guiding the student to practice a sport or the game of handball in our case. First of all, it is necessary for every student to understand the positive effects that sports in general and handball in particular have on health, well-being, social development and communication, but also on education and sports performance. The game of handball is a team sports game, so we can say that team spirit develops very well by practicing this sport. It captures the systems of its exercises, and

depending on the goal pursued, handball is both a means of physical education and a sport - a sports discipline.

The game of handball combines very well the essential motricity skills with the special ones, being a mental request that has an educative-formative character. [1]

The positive effects that the game of handball has on students are multiple. Through a conscious and active participation of the students, they move faster to the improvement phase thanks to fractional learning, within the physical education lessons.

They can develop harmoniously from all points of view. If we refer to playing handball at the age of 13-14, the general physical development at this stage is strongly influenced by the puberty period. The student grows very fast in height, in some periods it can reach up to one cm per month. This growth is achieved, mainly, at the level of the limbs and extremities, thus affecting the external appearance of the student, which sometimes becomes unaesthetic. At this stage, some attitudes of kyphosis, lordosis, scoliosis can be installed. [2]

In recent years, a system of sports competitions has been created that allows the training of a large number of students and young people in the systematic practice of sports branches. The importance of organizing this system of competitions is as follows: it is possible to compare both individual and team sports performances, from an educational point of view they play a very important role, they are an important element in order to promote the activity of physical education and sports. Considering that within the physical education and sports lessons, the teaching of sports games must be carried out respecting the following principles: learning the basic technical and tactical procedures within the complex structure, teaching the basic technical and tactical procedures in conditions close to the game, teaching basic technical and tactical procedures under stress. [3]

The sports game is loved by all students due to the complex nature of the physical exercises practiced in the form of a game, using an object, a ball, within which two teams compete according to well-established rules from the beginning. The game itself contributes to the achievement of the objectives of physical education and school sports through motor skills, by developing motor qualities and educating mental qualities, but also by ensuring a good density of the lesson. We can say that by practicing sports

games, students will educate their spirit of initiative, collective spirit, respecting tasks, assuming responsibilities, making decisions, developing the spirit of self-organization, self-leadership, independence. [4]

Handball is a sport game that in recent years has enjoyed great success among students, being played by both girls and boys. Handball can be played very easily at any age category in every year of the primary cycle, middle school and high school, having a small playing field, being easy to set up, the game being a dynamic one, varied by transitions from attack to defense, and the evolution of the score through the goals scored makes it interesting. The rules are few, simple and easy for students to learn. Learning and assimilating easily and very quickly, is included through the characteristics of technical procedures with the intercalation of motor qualities on a background of resistance in speed mode. Students who are talented and gifted from a motor point of view, facing the requirements of the selection process, can be guided to practice the game of handball, in accredited structures of sports clubs or associations. Thus, handball contributes to the achievement of the objectives of school physical education. [5]

The objectives of the game of handball are realized by: acquiring, consolidating, perfecting the technical procedures of the technical-tactical structures and the game, the rhythmic completion in learning of the technical procedures and technical-tactical structures with more complex ones, increasing the ability to act in an organized attack and defense, development of motor skills, education of physical qualities. If we notice, the model of physical ability is especially addressed to the particular development of the players, rather than the team in general. [6]

Analyzing all these aspects, students have different reasons for practicing sports activities or playing handball. This motivation comes from the awareness of the beneficial effects on students, but also due to the need to belong to a group, for affirmation, for socialization. Epuran M. believes that it is primarily related to the need for movement, and secondly self-affirmation. This motivation must come from within each participant, being rather difficult to measure, that's why we applied those questionnaires to see the motivation and what causes each individual student to

participate in activities specific to the game of handball. Intrinsic motivation comes from the direct relationship between the athlete and the sports activity. [7], [10]

The game of handball plays an important role in the field of psychopedagogy of sport, contributing to the analysis of the individual's motivational sources. [8] The use of motivational factors regarding the achievement of performances in the game has an effect on the psychopedagogy of sport, offering the opportunity to analyze in detail the individual's motivational sources. [9]

General motility is an important criterion for practicing the game of handball, but the level of development of coordinative capacities is the indicator recommended by specialists to develop the motor potential of students for their progress and evolution. [11]

METHODOLOGY

The research was carried out on a group of 60 students, of which 40 were boys and 20 were girls aged between 13 and 14. Some of the students systematically practiced other sports such as: football, volleyball, basketball, swimming, and some of them did not participate in any sports activity.

The first stage consisted in selecting the sample of students, they were between 13 and 14 years old, both girls and boys. Both the students and their parents were informed about the purpose of this study, the methods and means that will be used in the experiment, the objectives that are pursued during the application of the program, the tasks that must be performed by all participants in the study, they can withdraw from the program at any time without any obligation.

In the experiment they used as research methods: the observation method, the conversation method, the investigation method, the questionnaire method, the statistical and graphic method.

After applying the questionnaires and after receiving the consents from the parents and the students to participate in this study, we made a preparation plan and prepared the necessary materials for conducting the experiment.

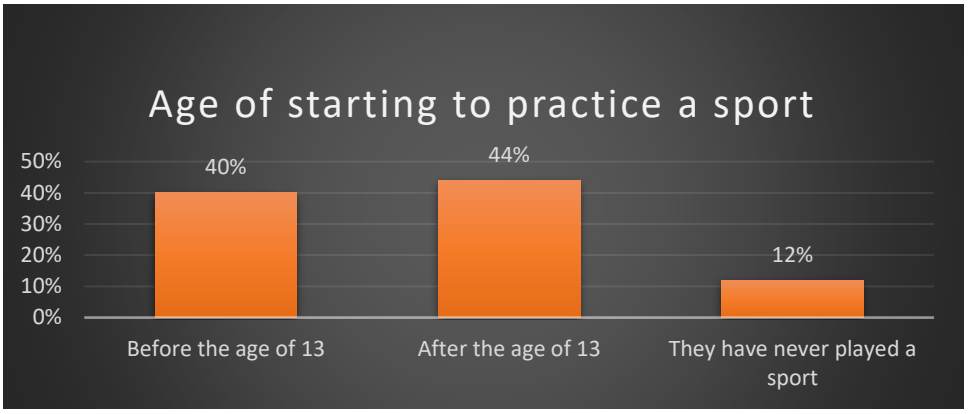

Fig.1 Age of starting to practice a sport

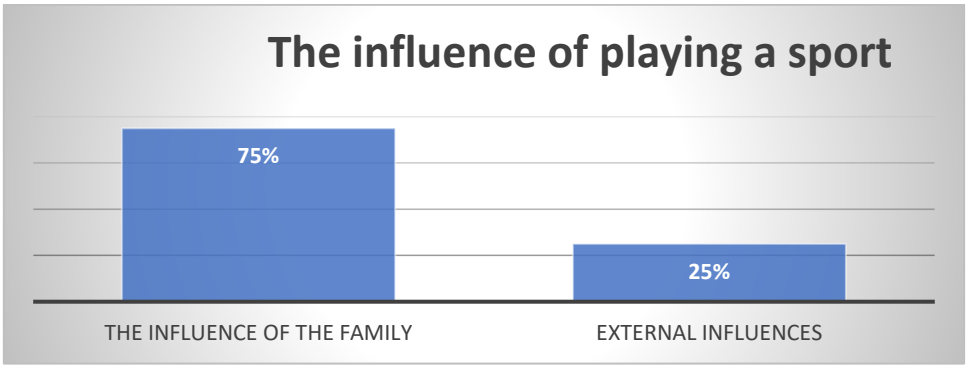

Fig. 2- The influence of practicing a sport

Students who practiced a sport both before the age of 13 and after the age of 13 chose football in proportion of 40%, basketball in proportion of 13%, volleyball with a percentage of 10%, handball with a percentage of 20%, and swimming with a percentage of 17%.

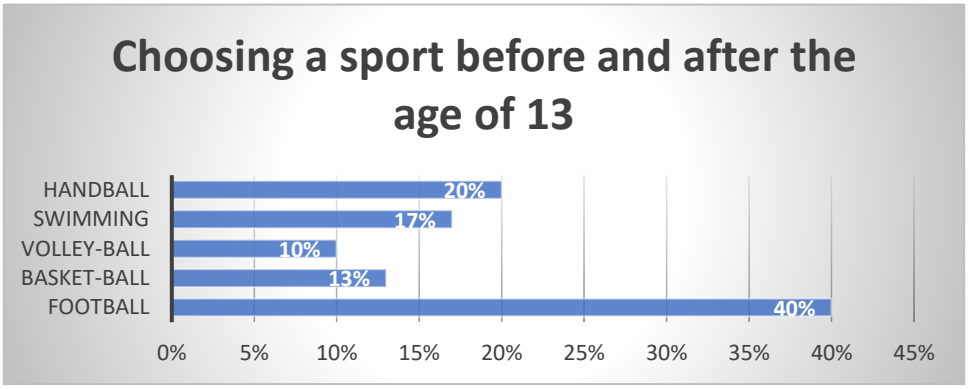

Fig. 3- Choosing a sport before and after the age of 13

The most sought-after reasons why students want to practice handball are: the desire to belong to a group (27%), the desire to socialize (20%), the desire to run (18%),

the desire to participate in sports competitions (20%), the desire for harmonious physical development (10%), and to all this is added the ability of the physical education and sports teacher to capture the student in the practice of handball (5%).

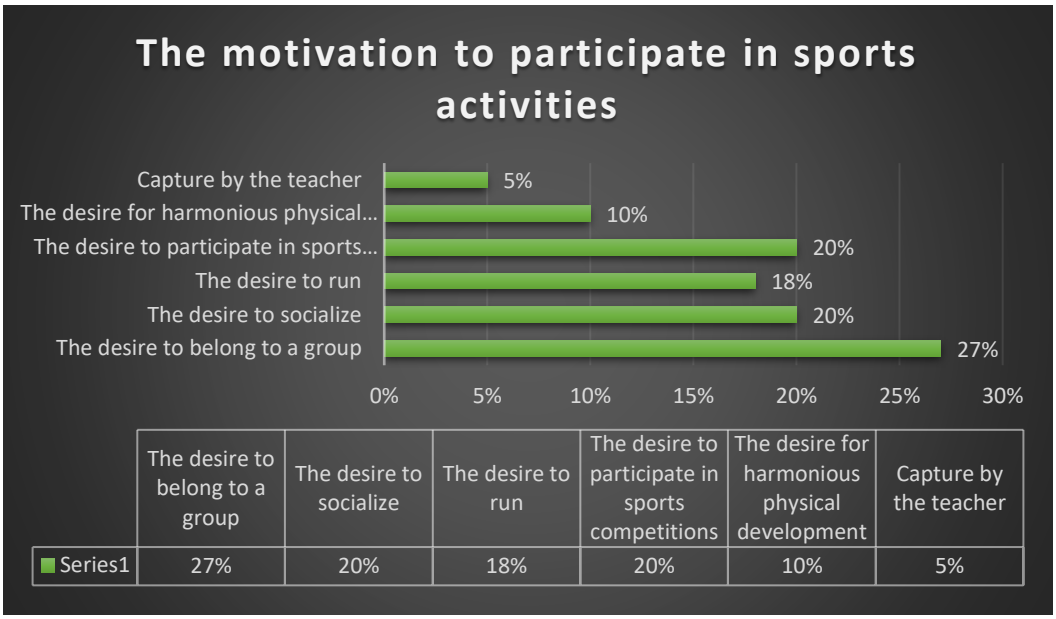

Fig. 4 - The motivation for participating in sports activities

Another motivation for the students to practice sports activities in general and handball in our case is the admiration from the parents, the family in a percentage of 70%. The remaining 30% represents the motivation created by the admiration of friends or teachers in proportion to 20%, and 10% of them practice sports activities or handball for pleasure.

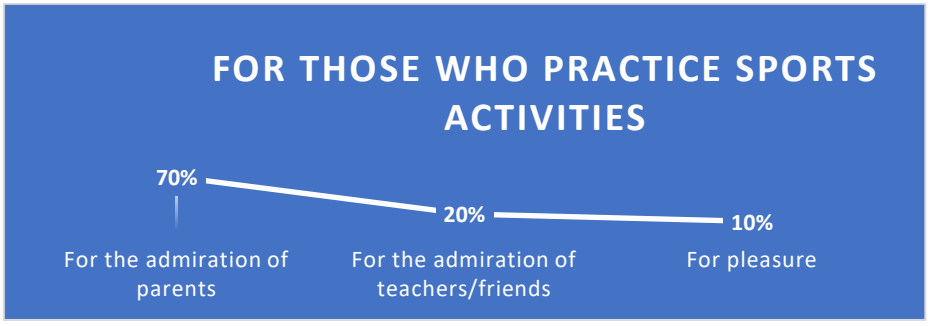

Fig. 5 – For those who practice sports activities

We analyze the factors that could lead to abandoning the practice of sports activities or the game of handball, from the sample of 60 students who completed the questionnaire, 45 students, 75% of them did not think of giving up the practice of the game of handball, or to the sports activities they practice and did not do during the study. This allows us to conclude that there is a very good motivation, both from the family

and from the outside, but the most important motivation is the intrinsic one, in which the student finds the resources necessary to practice a sport. The reasons why the 15 students, representing a percentage of 25%, abandoned the practice of handball or a sports activity during the study were: 10% school problems, 8% injuries, 7% other reasons.

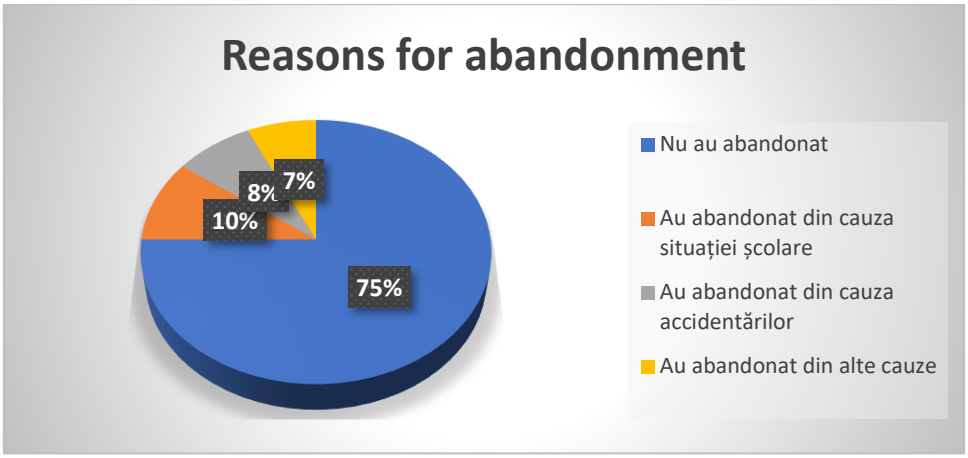

Fig. 6 – Reasons for abandoning the game of handball or sports activities

Marcen found in a study that the reasons for practicing sports activities are health and hygiene, physical and intellectual balance, the desire to participate in sports activities, fitness and fun. These aspects weighed more than the social reasons, those of becoming known, of gaining popularity. Kesend & Murphy (1989) interviewed female athletes in the United States and highlighted the main reasons identified for these athletes to become involved in professional sports. These were: achievement of evaluation and correction skills, intrinsic motivation through fun, and wish fulfillment. [10]

CONCLUSIONS

In conclusion, we can say that students are eager to practice handball or certain sports activities, especially after the age of 13. They want to participate in these sports activities for the desire to belong to a group, for admiration from family or relatives, for recognition of value in groups of friends or by teachers, for harmonious physical development. The reasons why they abandon the practice of handball or other sports activities are related to the school situation, injuries, or other situations such as a change of residence.

Acknowledgement

The authors of this work have taken all steps by which the subjects participating in the study were informed about all aspects related to the voluntary nature of their participation in this study. The information received from them is published, without negative repercussions on them. The present study complied with all the ethical norms of a research and the participants gave their consent to participate in this study.

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ANALYSIS OF TECHNICAL-TACTICAL AND PSYCHOMOTOR PERFORMANCE IN BADMINTON PRACTICE

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Abstract

Badminton, through its specific characteristics, requires both technical and tactical skills as well as the development of motor and psychomotor abilities, having a positive impact on overall physical fitness. It is assumed that the inclusion of an educational program based on badminton-specific exercises significantly contributes to improving the technical-tactical and psychomotor performance of middle school students by developing coordination, balance, spatial orientation, and other complex motor skills, compared to the standard physical education curriculum. The aim of this study is to evaluate the impact of an educational program based on badminton-specific exercises on the development of technical-tactical and psychomotor performance in middle school students, focusing on coordination, balance, spatial orientation, and complex motor structures to optimize the educational process during physical education classes. The results obtained highlight notable progress in the development of coordination, balance, spatial orientation, and other complex motor skills compared to the standard physical education curriculum.

Keywords: analysis, performance, technical, tactical, motor, badminton, students, middle school.

INTRODUCTION

Research conducted in the field of sports has highlighted various solutions for optimising the training process and promoting the use of innovative methods and techniques. These advancements have led to the development of equipment, facilities, and computerised technologies that have played an important role in improving the efficiency of sports preparation. In this context, studies by [6,11] emphasise the impact of computerised technologies on the evaluation of athletes' performances.Moreover, children's environment and lifestyle have negatively influenced their physical activity, as they often live in confined spaces with limited access to suitable conditions for play. However, this environment can stimulate children's adaptability to new motor

situations, fostering motor learning. The study conducted by [8] reveals differences in the coordination abilities of students from rural and urban areas, highlighting the impact of various environmental conditions on motor development. In terms of school physical education, badminton plays an important role in the physical and psychomotor development of students, particularly at the middle school level. This sport, which involves speed, coordination, and precision, requires technical-tactical skills as well as motor and psychomotor abilities, contributing to the improvement of overall physical fitness and the development of competencies such as coordination, balance, and spatial orientation. Thus, badminton represents an ideal opportunity to stimulate the harmonious development of students, allowing them to learn tactical strategies and fundamental techniques specific to the sport. The educational design of physical education lessons is a complex and challenging activity influenced by factors such as school program regulations, environmental conditions, student diversity, and teacher experience. A study by [7] underscores the importance of adapting learning units to the needs and characteristics of students, considering the specific context of each school.

The analysis of psychomotor and technical-tactical performance in badminton is not limited to assessing physical progress but also aims to identify effective teaching methods for improving physical education lessons. The study [12] highlights the use of computer technology in evaluating sports performance, and the mindset of a physical education teacher plays a crucial role in optimising the instructional-educational process. According to studies by [1,13], a significant openness (91%) of teachers to innovation and adaptability can support the optimization of students' physical fitness.

Furthermore, studies by [10] emphasise the importance of capitalizing on students' motor, technical-tactical, psychological, and attitudinal potential to optimise physical performance. In this context, research conducted by [2] shows that badminton activities, implemented in a school setting, can significantly contribute to the development of children's fundamental motor skills while also stimulating their motivation for movement. Therefore, badminton proves to be an effective activity for the physical and motivational development of primary school students. The attractiveness of this sport, highlighted in the study by [3], supports the active involvement of children in school physical activities and the development of essential

skills for their future performances. The analysis of technical-tactical and psychomotor performance in badminton practice reveals the importance of this sport in the physical and psychomotor development of students. Badminton, by its nature, simultaneously demands complex motor skills and tactical strategies, contributing to improved coordination, balance, spatial orientation, and the development of essential competencies for physical performance. Studies show that including this sport in school curricula supports not only physical progress but also increased motivation for movement, encouraging students to actively participate in physical education lessons.

At the same time, implementing effective teaching methods tailored to the individual needs of students is essential for optimising the educational process. Thus, badminton proves to be an excellent choice for developing fundamental motor skills and promoting an active, healthy lifestyle, significantly contributing to improving students' technical-tactical and psychomotor performance.

The aim of this study is to evaluate the impact of an educational program based on badminton-specific exercises on the development of technical-tactical and psychomotor performance in middle school students, focusing on coordination, balance, spatial orientation, and complex motor structures to optimize the educational process in physical education classes. The main objective of this research was to identify the initial level of students' technical-tactical and psychomotor performance using specific badminton tests (e.g., forehand and backhand strokes, general dynamic coordination, spatial orientation). Furthermore, we wanted to develop and implement a program that includes methods and tools specific to badminton in physical education lessons and to evaluate the progress made by students following the implemented program using the same specific tests. Lastly, we compared the technical-tactical and psychomotor performance between the experimental and control groups.

We hypothesized that the inclusion of an educational program based on badminton-specific exercises significantly contributes to improving the technical-tactical and psychomotor performance of middle school students by developing coordination, balance, spatial orientation, and other complex motor skills, compared to the standard physical education curriculum.

METHODOLOGY

The main research methods we the analysis of specialized literature, observation method, pedagogical experiment method, testing method, mathematical-statistical method, and tabular-graphical method.

The study included a sample of 50 middle school students from "Alexandru Ioan Cuza" School in Fălticeni, divided equally into two groups: experimental group: 25 students (15 boys and 10 girls) who participated in a specific training program based on badminton and control group: 25 students who followed the standard physical education curriculum.

The experiment was conducted during Module III, lasting 7 weeks. Each week included two physical education lessons, each lasting 50 minutes. Inclusion criteria: Age and study level: Middle school students (grades VI-VII), aged 11 to 13 years. Regular participation in physical education classes. No medical contraindications for participating in physical education lessons. Students without significant prior experience in badminton to ensure similar starting conditions among participants. Ethical considerations: Parental consent was obtained after detailed information was provided about the study's purpose, methods, duration, benefits, and potential risks. Participation was voluntary, and students were informed that they could withdraw from the study at any time without consequences. To protect participants' identities, collected data was anonymized and used exclusively for research purposes.

Table 1. Programs Badminton Exercises for Module III

Week	Lection 1 - Technical-tactical exercises	Lesson 2 - Psychomotor and Tactical Exercises
1	Objective: Mobility and basic techniques	Objective: Agility and efficient service
	- Drill Field Trip: Sideways, forward and backward steps (10x in each direction) - Forehand și backhand: Basic shots with partner (10x on each side) - Drop-shot: Short shots with precise placement (10x on each side)	- Short and long service exercise: Short and long serves on each side (10x each) - Field running intervals: 30 seconds speed, 30 seconds recovery (6-8 repetitions) - 1 on 1 game: Focus on fast movement and precise placement
2	Objective: Shot control and movement strategy	Objective: Reflexes and direction control
	- Forehand/Backhand Drill: Correctly placed shots in the corners (10x on each side) - Drill with serve: Practicing short or long serves and returns (10x each)	- Quick reaction exercise: Partner throws the random flyer and the student must hit quickly (15 throws) - 1-on-1 match: Focus on quick reaction and placing the butterfly at unpredictable angles

Week	Lection 1 - Technical-tactical exercises	Lesson 2 - Psychomotor and Tactical Exercises
	- Agility and change of direction: 3 sets of 30 seconds of fast travel (crooked and diagonal)	- Jumps and speed intervals: Jumps on the spot and 30-second running intervals (10 reps)
3	Objective: Improve services and smash	Objective: Mobility and game tactics
	- Long and short serve: Practicing serves with exact placement (10x on each side) - Smash with partner: Hitting the butterfly from a high position (10x) - Power Jumps: Jumps to simulate a smash (3x 10 jumps)	- Fast Field Movement: Quick Change Drill Between Corners (10x) - Tactile play: Short exchanges with a partner to train the placement of the flyer - Running intervals: 30-second speed interval and 30-second break (10 reps)
4	Objective: Control of shots under pressure	Objective: Reflexes and quick reaction
	- Serve & Return Under Pressure: Practicing Fast Return Serves (10x each) - Controlled Smash: Precise Placement Butterfly Kicking Exercise (10x) - Field Travel: Quick Turn Drill and Place Flyer (10x)	- Quick reaction with the steering wheel: Partner throws the flyer in random directions (15 throws) - Quick Recovery Game: Quick Changes of Direction and Butterfly Placement (15 Exchanges) - Sprint intervals: 10-meter sprint, 30-second sprint/30-second break (10 rounds)
5	Objective: Mobility and physical endurance	Objective: Doubles technique and tactical reaction
	- Fast Move Drill: 4-Corner Fast Move (10x) - Jumps on the spot: Jumps for agility and strength (10x) - Running intervals: 30-second sprints followed by a 30-second break (10 rounds)	- 2v2 Game: Focus on Communication and Team Coordination - Double Tactile Drill: Using Space to Place Flyer (15 Shifts) - Double Game: Team Exercise to Practice Collaborative Moves
6	Objective: To improve doubles tactics	Objective: Reaction speed and steering wheel placement
	- Doubles Game: Practicing Court Covering Tactics (10 Exchanges) - Synchronized double-handed travel: Team movement exercises (10x) - Steering wheel placement in corners: Practice placing the flyer (10x on each side)	- Quick reaction and placement: Partner throws The flyer and the receiver must hit quickly and accurately (15 throws) - Anticipation Exercise: Opponent's Shot Anticipation Exercise (10x) - Jumping on the spot: 10 quick jumps for agility
7	Objective: Final testing and evaluation of progress	Objective: Evaluation matches and final feedback
	- Performance Testing: 1-on-1 games to evaluate progress on serve, smash and placement (3 games) - Feedback & Progress Analysis: Shot & Move Analysis - Resistance jumps: 3 sets of 10 physical endurance jumps	- Full matches: 1 lab1 or double matches to apply everything learned - Psychological assessment and feedback: Analysis of execution from matches - Match Completion: Feedback and Discussion of Strengths and Weaknesses

Each week has been designed to improve students' fundamental skills, including basic techniques, mobility, agility, quick reactions and correct butterfly placement.

RESULTS

The purpose of data analysis is to assess the current level of physical condition of athletes and their potential to achieve future performance [9]. We will analyze and interpret the results obtained from the tests applied at the beginning and end of the program, as well as the differences in the performance of the students in the participating groups. This data will be used to evaluate the effectiveness of the educational program implemented, providing an insight into the progress made following the exercises specific to the game of badminton.

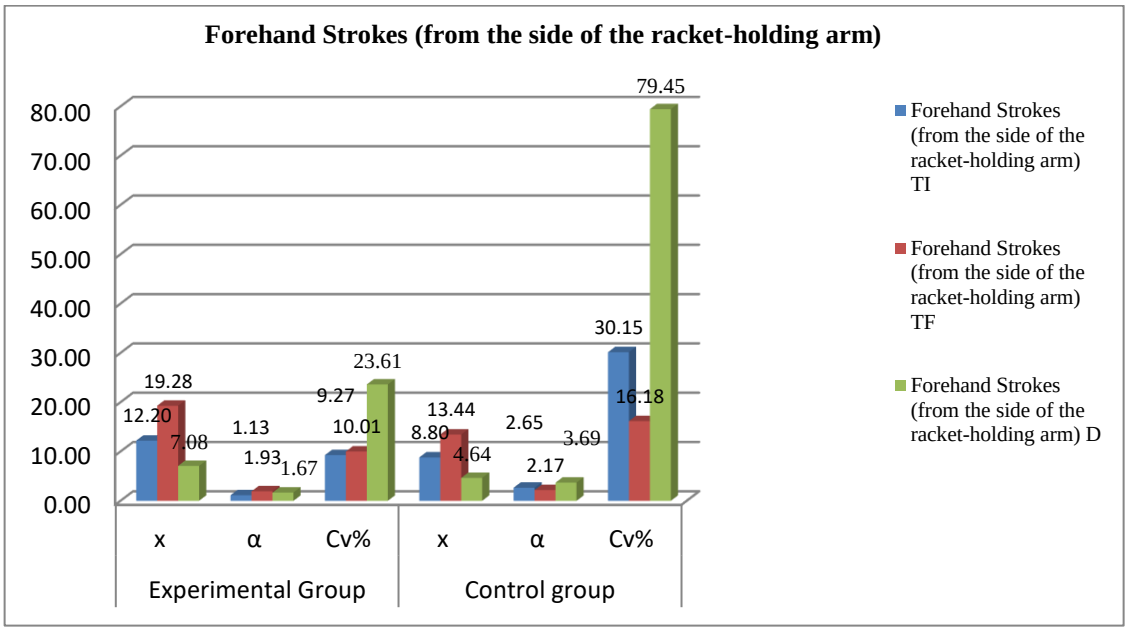

Figure 1. Forehand Strokes (from the side of the racket-holding arm)

It can be seen in Fig.1 that the experimental group recorded a significant increase in the average performance of forehand shots (D = 7.08) compared to the control group (D = 4.64), which highlights the effectiveness of the specific training program. The high consistency of the results in the experimental group (low Cv%) and the large variation in progress in the control group (Cv% = 79.45% for D) confirm the superiority of the applied intervention.

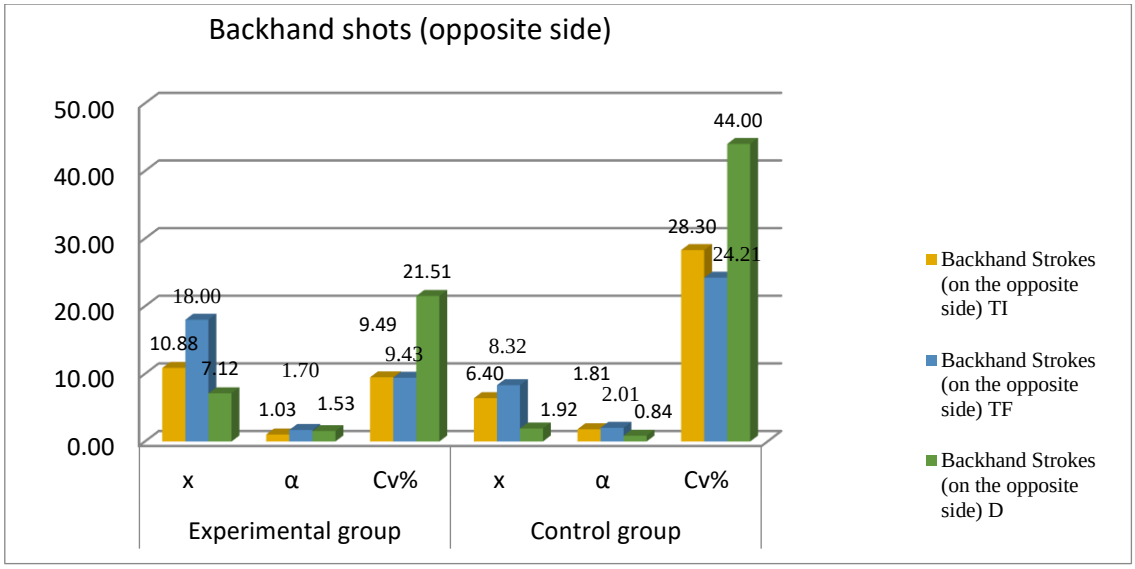

Figure 2. Backhand shots (opposite side)

The experimental group recorded a significantly higher progress in backhand shots (D = 7.12) compared to the control group (D = 1.92), highlighting the effectiveness of the means applied. The high consistency of the results in the experimental group (low Cv%) and the large variation in progress in the control group (Cv% = 44.00% for D) confirm the superiority of the specific means.

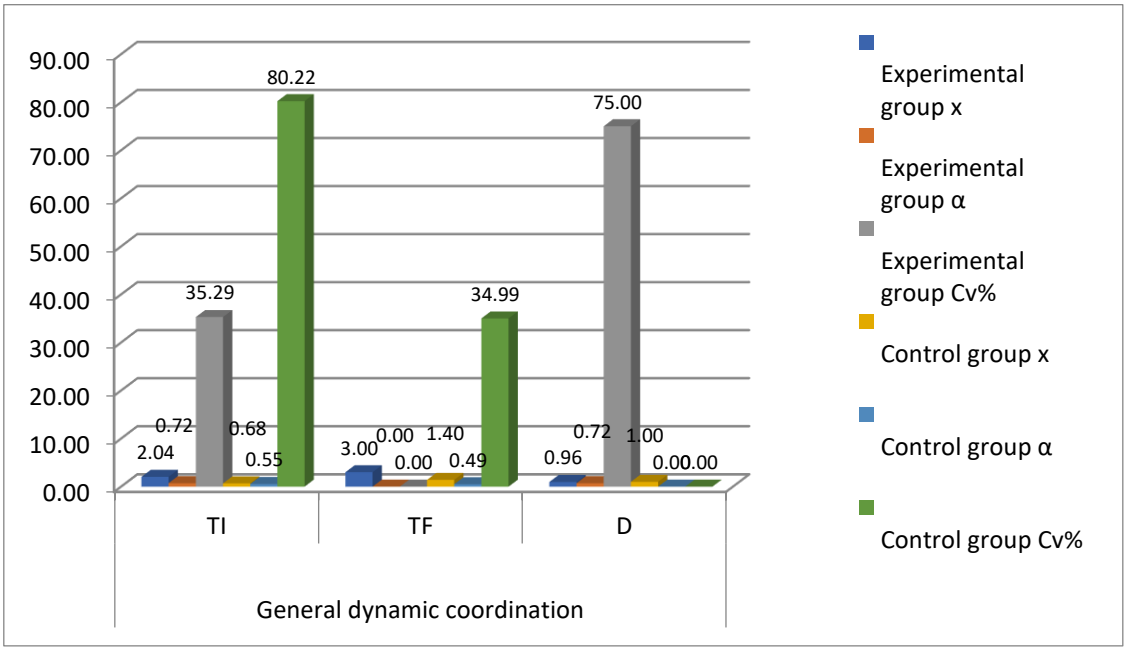

Figure 3. General dynamic coordination

The experiment group made remarkable progress in overall dynamic coordination (D = 0.96), similar to the control group (D = 1.00), but with a higher consistency in results (Cv% for TI and TF in the experiment group being more

balanced). The high variability of progress in the experiment group (Cv% for D = 75.00) suggests greater individual differences in learning compared to the control group.

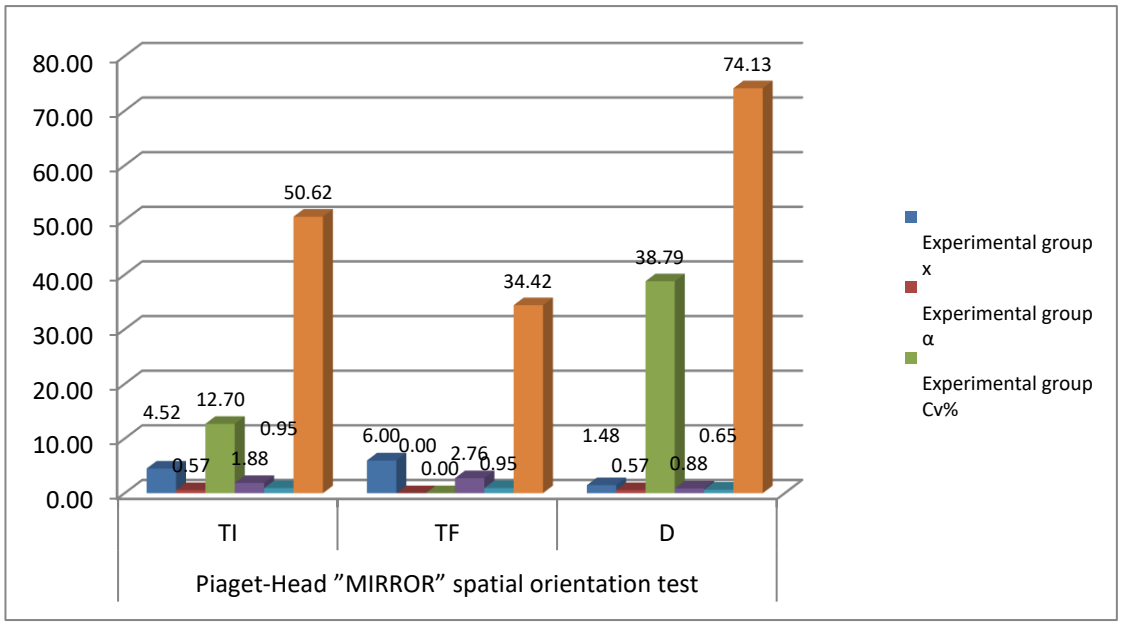

Figure 4. Piaget-Head "MIRROR" spatial orientation test

The experimental group achieved significantly higher progress in the spatial orientation test (D = 1.48) compared to the control group (D = 0.88), highlighting the effectiveness of the applied intervention. Also, the consistency of the results in the experimental group (Cv% for D = 38.79) is superior to that in the control group (Cv% for D = 74.13), demonstrating a more uniform improvement in performance.

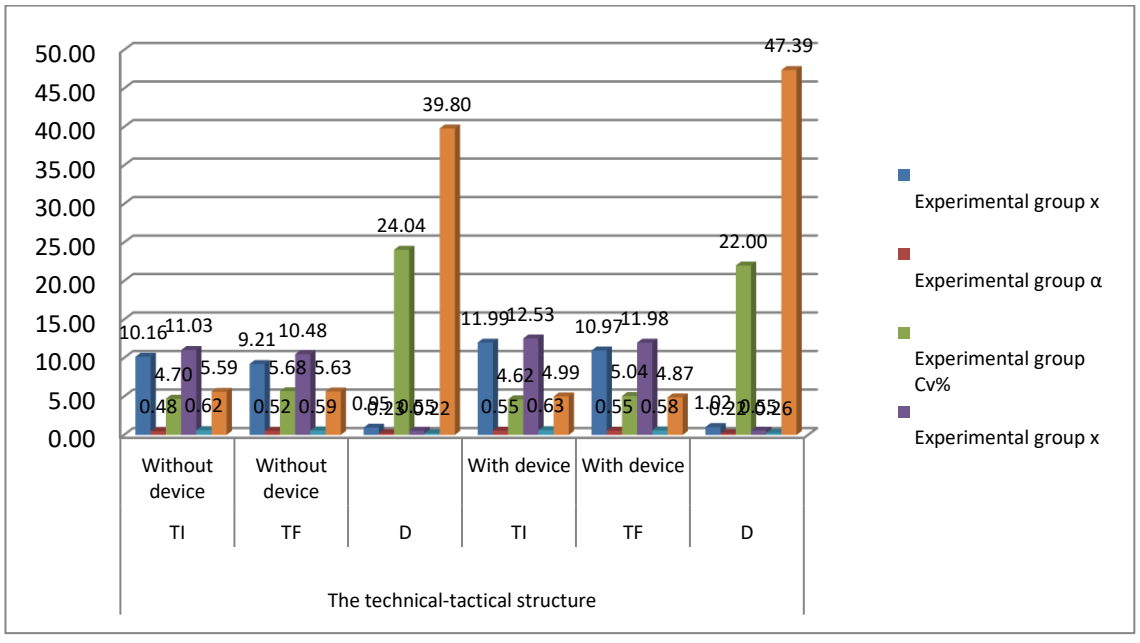

Figure 5. The technical-tactical structure

The experiment group made greater progress in both non-brace (D = 0.95) and apparatus (D = 1.02) executions compared to the control group (D = 0.55 for both conditions), which reflects the effectiveness of the specific intervention. The consistency of the results is higher in the experimental group (Cv% for D = 24.04 and 22.00) than in the control group (Cv% for D = 39.80 and 47.39), demonstrating a superior uniformity of progress.

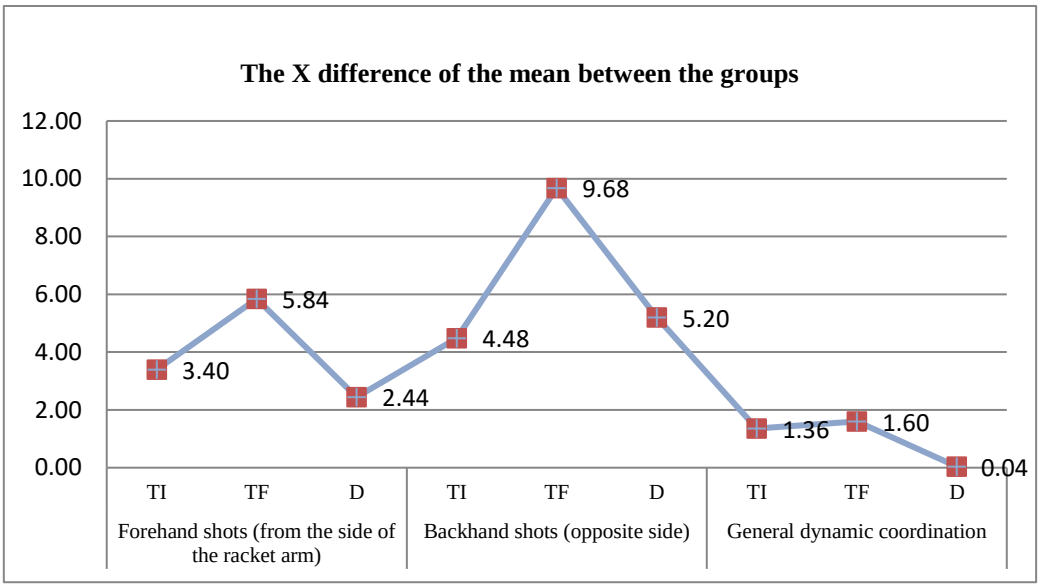

Figure 6. The X difference of the mean between the groups

The experimental group recorded significantly superior progress in forehand shots, with the average difference between the groups increasing from 3.40 (TI) to 5.84 (TF), with a progress advantage (D) of 2.44 in its favor. At the backhand shots, the impact of the program was even more obvious, the mean difference between the groups increasing from 4.48 (TI) to 9.68 (TF), with a clearly higher progress of the experimental group (D=5.20,D = 5.20,D=5.20). In general dynamic coordination, progress was almost similar between the two groups (D=0.04, D = 0.04, D=0.04), suggesting a comparable influence of means. The results confirm the effectiveness of specific lessons for improving technical-tactical performances, especially in shots, but less on general coordination.

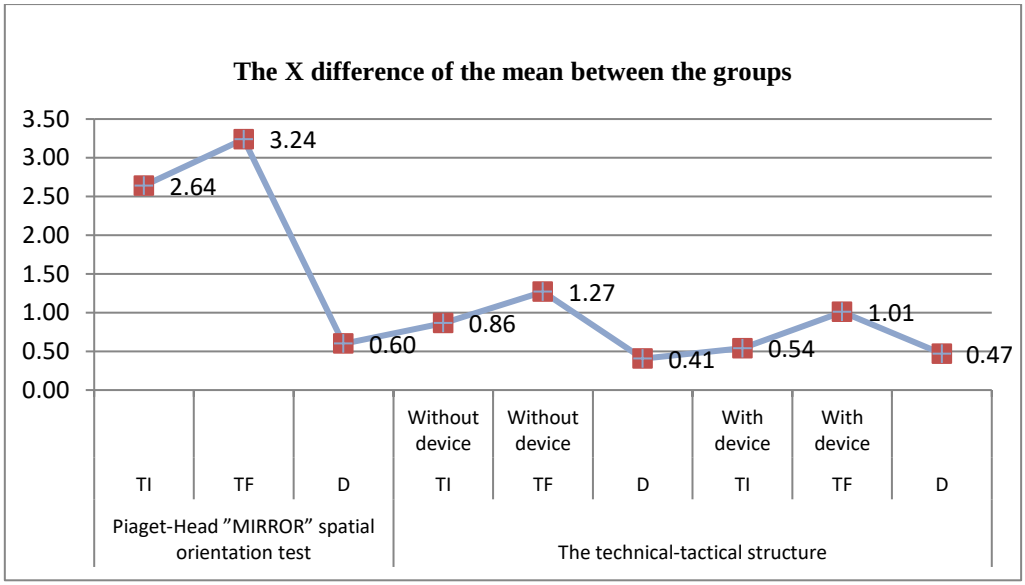

Figure 7. The X difference of the mean between the groups

In the Piaget-Head spatial orientation test "MIRROR", the X difference in the mean between the groups was 2.64 for TI and 3.24 for TF, with a progress (D) of 0.60, indicating a slight improvement in performance in the TF group. In the technical-tactical structure, the differences between the groups without apparatus are 0.86 for the TI and 1.27 for the TF, with a progress (D) of 0.41 in favor of the TF group. In the case of the apparatus groups, the difference between TI and TF is 0.54 and 1.01, and the progress (D) is 0.47, indicating a slightly larger advance in the TF group.

DISCUSSIONS

In the study [4] programs based on psychological strategies of self-speech and mental image had a significant impact on the improvement of badminton motor skills and self-confidence, with variable effects depending on the specific combinations of trained and motivational functions. The purpose of another article is to provide physical education teachers with guidance for creating meaningful instructional tasks and to introduce them to effective ways of teaching badminton, based on three fundamental principles of the approach to the game [5], and another study investigated the evolution of playing skills and tactics in badminton at different levels of development of high school students, highlighting significant progress as the skill level increased, but also the use of immature strokes and the decrease in the frequency of standard techniques at all levels[14].

CONCLUSIONS

The study shows that the implementation of a didactic program based on badminton-specific exercises had a significant impact on the improvement of the technical-tactical and psychomotor performances of secondary school students. Advances in coordination, balance, spatial orientation and other complex motor skills demonstrate the effectiveness of this type of approach compared to the standard physical education program.

The comparison of performance between the study groups showed that the students who followed the badminton-based program made greater progress than those who participated in the traditional program, thus confirming the hypothesis of the study and emphasizing the importance of integrating sports-specific exercises into the physical education curriculum for the development of students' motor and psychomotor skills.

The didactic program made with badminton means emphasizes the importance of combining technical-tactical and psychomotor exercises for the development of students' physical and tactical skills. The structure of the lessons allowed the students to improve both their individual technique (shots, serves, smashes) and their ability to react quickly, mobility on the court and teamwork skills, in the case of doubles games.

The final test showed significant progress in all technical-tactical and psychomotor aspects, and the feedback provided to the students was essential for strengthening learning and correctly applying skills in a real game context.

The experiment group made significant progress in all test categories. For example, in forehand shots, the average increased from 12.20 (TI) to 19.28 (TF), with a difference of 7.08, and in backhand shots, the progress was even more obvious, with the average increasing from 10.88 (TI) to 18.00 (TF), with a difference of 7.12. As for the general dynamic coordination, the experimental group registered an increase from 2.04 (TI) to 3.00 (TF), with a difference of 0.96, and in the Piaget-Head spatial orientation test "MIRROR", the progress was 1.02 (from 10.16 to 9.21). These substantial advances suggest that the program has had a significant impact on students' technical-tactical and psychomotor skills.

Variability of results and differences in performance: The control group experienced lower performance and greater variability of results. For example, in forehand shots, the average increased from 8.80 (TI) to 13.44 (TF), with a difference of 4.64, and in backhand, the progress was only 1.92 (from 6.40 to 8.32). In terms of general dynamic coordination, the difference was only 0.68, and in the "MIRROR" Piaget-Head spatial orientation, the difference was 0.55. These results emphasise a more modest performance compared to the experimental group, and the higher variability (Cv% of 30.15% in forehand shots and 44.00% in backhand) indicates greater inequality in the progress of students in the control group.

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EVALUATION OF THE EFFECT OF CORE STRENGTH TRAINING ON FMS SCORES IN TENNIS ATHLETES

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Abstract

This study investigated the effects of core strength exercise programmes on functional movement analysis in tennis athletes playing in a private sports club in Istanbul. A total of 40 volunteers participated in the study. The participants were divided into two groups as core strength group (SG) (n=20) and control group (CG) (n=20). The mean age of the 20 participants in the CG was 15.15±0.81 years, body weight was 42.36±2.21 kg and height was 140.25±8.41 cm. The mean age was 14,87±0,88 years, body weight was 42,63±1,96 kg and height was 138,81±7,91 cm. In the study, height-weight, reach-reach, Y-balance, sit-up, plank and FMS tests were taken as pre-post tests and core strength training was applied to SG 2 days a week for 8 weeks. As a result of the analyses, statistically significant differences were found for sit and reach (t=4,565, p<.05), plank (t=6,778, p<.05), sit-up test (t=5,944, p<.05), FMS (t=5,136, p<.05), while no difference was found for Y-balance test right foot (t=-1,054, p>.05), Y-balance left foot (t=0,274, p>.05). As a result of the study, it was determined that core strength training programmes were effective on FMS scores in athletes. It is thought that it can be used in addition to strength training in athletes.

Keywords: Tennis, functional movement screen, core, strength training.

INTRODUCTION

Tennis is a sport played on a hard and smooth ground using a piece of equipment called a racket. In this sport, a small felt-covered ball is hit and the ball passes over or around the 91 cm high net in the centre of the court (Kermen, 2002). Tennis, like other sports, is a branch that requires high performance and includes tactical, technical and physical skills to ensure that athletes win. It is also known as a visually impressive and popular sport due to its aesthetic movements. Tennis is a sport that impresses spectators and attracts the participation of many people. This sport is played in many countries around the world and increases the tourism potential of these countries. Tennis

competitions are supported by big organisations and promotions, and big prizes are awarded (Ölçücü et al., 2012). Tennis is one of the most popular sports branches for both professional and recreational purposes (İmamoğlu, 2009). In recent years, it has been seen that athletes apply training techniques such as the core training model to improve their performance. Studies show that core training improves basic motoric characteristics and increases the performance of athletes (Görür, 2020; Hsu et al., 2018; Alpşahin, 2018).

Core exercises target the muscles that regulate and control the movement of the hips, lower back and abdomen. These exercises are a common method of strengthening the muscles used to stabilise the hips and spine. These muscles work together to stabilise the body during movement. Unlike weight training, the core training method aims to improve athletic performance and maintain strength during rehabilitation (Egesoy et al., 2018). The core plays an important role as an area that provides strength between the upper and lower body. The entire movement flow of athletes is transferred from the core to the extremities. As in daily life activities, it is important for athletes to have strong core muscles for waist stabilisation during weight training. Core training includes abdominal, thoracolumbar, hip and pelvic musculature, which provide stability for mixed body movements, including swinging and throwing movements. Healthy individuals need strong and durable core training to prevent injuries and improve athletic performance. Strength training improves the nerve pathway (drive) and the magnitude and rate of impulses sent to the target muscle. The increase in nerve conduction is manifested by an increase in the rate of action potentials and is associated with both an increase in muscle force production and an increase in the rate of force production. In order to improve these characteristics, various training methods are applied and evaluated in terms of performance improvement. There are various test materials used to make these evaluations. Functional Movement Assessment (FMS) is a system used to evaluate human movement in the field of sport and health worldwide and is accepted and applied by many international health and fitness institutions.

Therefore, many teams use FMS tests to evaluate athlete performance. This study was conducted to determine the effect of core strength training on FMS scores in tennis athletes. The aim of this study was to evaluate the effect of core strength training on

FMS scores in tennis athletes. The effects of core strength exercises on the functional movement system were compared in a core strength group and a control group for 8 weeks.

METHOD

Research Model

In this study, experimental design, one of the quantitative research methods, was used. Quantitative research is a type of research that makes the phenomenon discussed objective, observable and measurable. The issues addressed in quantitative research projects are presented in a way that can be expressed with numerical data. The experimental design is based on quantitative research on determined groups (Özmen & Karamustafaoğlu, 2019). Firstly, height, weight, Y-balance, plank, sit-up, push-up, vertical jump (CMJ) tests were taken in the morning session and single repetition maximal strength tests were taken in the afternoon. After 8 weeks of strength training, the tests were repeated. After the participants were reminded about the training programme protocol before starting their training, each participant performed the training protocol of the group they were included in the main phase after the standard warm-up phase and the preparation phase and completed the training with the cooling phase. For the warm-up phase, light jogging on a treadmill (Lifefitness, USA) at a speed of 6 km.sec-1 for 5 min, 6 dynamic stretching movements based on large muscle groups with 4 repetitions each for weight lifting preparation, 2 sets of jack knife and superman movements with 10 repetitions as preparation for training lifts were performed. For the cooling phase, 10 static stretching movements involving large muscle groups, each lasting 6-8 seconds, were performed while standing.

Participants

In the study, 40 volunteers aged between 14-16 years, who did not have any cardiovascular disease, blood disease, chronic disease or joint injury in the last 1 year, participated in a private tennis centre located in Bakırköy district of Istanbul province.

The mean age of the core strength group was 15.15±0.81 years, body weight was 42.36±2.21 kg and height was 140.25±8.41 cm. The mean age of the control group was 14.87±0.88 years, body weight was 42.63±1.96 kg and height was 138.81±7.91 cm.

Participants were asked to eat at least 2 hours before the tests. The participants were divided into 2 groups, each consisting of 20 people, as control group (CG) and core strength group (SG) by simple random sampling method. It was assumed that all individuals participating in the study understood the importance of the study and the tests. It was assumed that all individuals participating in the study performed maximal performance during the tests and performed strength training voluntarily. The study was limited to individuals who regularly attended training at least 3 days a week for at least 1 year. All participants were informed in detail about the purpose and importance of the study, possible risks and the ability to withdraw from the study at any time in accordance with the Declaration of Helsinki, and a consent form was filled out and signed. Nişantaşı University Ethics Committee approval was obtained for the study (No 20240104-178).

Data Collection Tools

Height, weight, flexibility, balance, plank, sit-up and FMS scores were obtained for the pre- and post-tests.

Height-Weight Measurement

'Participants' height and body weight were measured using a stadiometer (Holtain, UK) with an accuracy of 0.1 cm and a digital scale (Seca, Vogel and Halke, Hamburg) with an accuracy of 0.1 kg. Height measurements were recorded in metres in anatomical posture, bare feet, feet completely on the ground, heels together and in contact with the wall, knees tense and body in an upright position, with reference to the point where the tip of the head touches the stadiometer table. Body weights were measured in light sportswear (shorts and t-shirt), bare feet and anatomical posture. Each measurement was performed twice and the mean of these measurements was used as descriptive statistics.

Y Balance Test

The 'Y Balance Test', which is a method used to evaluate dynamic postural control, uses a 'Y' shaped pattern drawn on the floor with the help of tape. Numbers in centimetres are placed on this pattern and measurements are made using these numbers during the movements of the athletes. During the balance test, the participants are asked to keep their hands at waist level and place their heels on the floor. They are also

required to make a light touch to the farthest point with the fingertip of the reaching foot. The measurements are performed in a series of movements in which the athletes reach barefoot in three different directions: anterior (ANT) reach measures the distance the participant reaches from the toe of the toe in the centre, while posterolateral (PL) and posteromedial (PM) reach measures the distance from the heel of the foot to the farthest point they can reach. Athletes perform the test three times in each direction, totalling nine times. Errors such as athletes transferring their body weight to the reaching foot, separating the heel of the stance foot from the ground, or separating their hands from the hips during the measurement are not accepted and the measurement is repeated if such errors are recognised (Enquist et al., 2015). 'The leg length of each participant is recorded by measuring the distance from the anterior superioriliac point to the distal part of the medial malleolus bilaterally in the supine position.' All reaching distances are recorded in centimetres and once the data are obtained, the distances obtained in each direction are normalised using the formula 'Best Reach Distance/Leg Length × 100 = % Most Reach Distance' to remove the effect of leg length (Gribble and Hertel, 2004).

Core Zone Plank Test

Plank test' is an exercise based on maintaining the balance of the body in a prone position towards the floor, on the elbows and feet, with the heels and head forming a straight line. During the test, the participant takes the plank position with the start command. If the position is disturbed (such as the hips falling down or rising upwards), a warning is given. The test is terminated for the athlete who receives three warnings. How long the participant stayed in the plank position was recorded in seconds (Boyacı, A. & Tutar M., 2018).

Sit and Reach

The torso (waist and hips) is tilted forward and it is asked to reach as far forward as possible without bending the knees, with the hands in front of the body. The subject tries to reach the farthest point in this way and waited 2 seconds at the last point and recorded.

Functional Movement Analysis

For the Functional Movement Assessment (FMS) test, a protocol consisting of 7 basic movements including deep squatting, high stepping, stepping forward in a straight line, shoulder mobility, active straight leg raising, trunk stability and rotation stability was applied (Peate et al., 2007; Warren et al., 2018).

Each movement pattern was qualitatively analysed by the researcher and given a score between 0 and 3 according to the degree of movements required to complete the movement or the presence of pain. The scores were then summed and the participants' overall FMS scores were determined. Scoring conditions;

- 3 = Ability to correctly complete the movement pattern without any predefined compensation;
- 2 = Movement with any of the movement pattern specific compensations;
- 1 = Inability to realise the movement pattern;
- 0 = Presence of pain in any part of the movement pattern (Warren et al., 2018; Chang et al., 2015).

Sit-up Test

The number of sit-ups that the participants could perform at maximum repetition in one minute was recorded. The participants lay on their backs on the floor, bent their knees and pressed the soles of their feet to the floor. Afterwards, they were asked to lift their heads upwards and repeat the movement as many times as they could.

RESULTS

Table 1. Comparison of pre and post test values of the groups

	Pre-test				**Post-test**			
	SG (n=20)	**CG (n=20)**			**SG (n=20)**	**CG (n=20)**		
	Mean±Sd	**Mean±Sd**	**t**	**p**	**Mean±Sd**	**Mean±Sd**	**t**	**p**
Sit & Reach (cm)	16,65±3,97	16,60±3,2	0,43	,966	19,10±3,65	17,35±3,06	1,64	,109
Y Balance-Right	82,31±5,92	85,28±5,4	-1,64	,109	83,47±5,49	86,82±5,34	-1,89	,066
Y Balance-Left	83,47±5,85	87,28±6,2	-1,85	,072	84,57±7,18	88,46±6,10	-1,84	,073
Plank (sec)	48,50±8,12	46,80±6,66	0,72	,474	63,60±8,53	48,35±6,76	6,26	,000*
Sit-up (count)	22,0±5,12	21,30±3,37	-0,51	,613	28,00±4,40	22,65±3,39	4,30	,000*
FMS (score)	13,20±3,13	15,82±5,16	-1,92	,062	15,50±2,54	16,44±4,45	-0,79	,461

When the table is examined, no significant difference was found in the pre-test data between the groups, but a significant difference was found in the post-test data in CG (63.60±8.53) and CG (48.35±6.76) (0.000) (p<0.05).

Table 2. In-group comparison of pre-post test values

	SG				CG			
	Pre-test	**Post-test**			**Pre-test**	**Post-test**		
	Mean±Sd	**Mean±Sd**	**t**	**p**	**Mean±Sd**	**Mean±Sd**	**t**	**p**
Sit & Reach (cm)	16,65±3,97	19,10±3,65	-6,97	,000	16,60±3,29	17,35±3,06	-6,09	,000*
Y Balance-Right	82,31±5,92	83,47±5,49	-3,56	,002	85,28±5,49	86,82±5,34	-8,03	,000*
Y Balance-Left	83,47±5,85	84,57±7,18	-3,67	,002	87,28±6,27	88,46±6,10	-5,27	,000*
Plank (sec)	48,50±8,12	63,60±8,53	-7,66	,000	46,80±6,66	48,35±6,76	-4,50	,000*
Sit-up (count)	22,0±5,12	28,00±4,40	-8,11	,000	21,30±3,37	22,65±3,39	-5,31	,000*
FMS (score)	13,20±3,13	15,50±2,54	-6,09	,000	15,82±5,16	16,44±4,45	-,345	,735

When the table is examined, a significant difference was found in reach-reach (0.000), y-balance right (0.002), y-balance left (0.000), plank (0.000), sit-up (0.000), fms (0.000) data. In the CG group, a statistically significant difference was found in reach-reach (0.000), y-balance right (0.000), y-balance left (0.000), plank (0.000), sit-up (0.000) data.

Table 3. SG ve CG fark ortalamalarının karşılaştırılması

Pre-Post Test	**Group**	**N**	**Mean±Sd**	**t**	**p**
Sit & Reach (cm)	**SG**	20	2,45±1,571	4,565	,000*
	CG	20	,750±,550		,000*
Y Balance-Right	**SG**	20	1,15±1,447	-1,054	,299
	CG	20	1,54±,862		,300
Y Balance-Left	**SG**	20	1,34±1,640	0,274	,786
	CG	20	1,22±1,041		,786
Plank (sec)	**SG**	20	15,10±8,807	6,778	,000*
	CG	20	1,55±1,538		,000*
Sit-up (count)	**SG**	20	6,00±3,308	5,944	,000*
	CG	20	1,35±1,136		,000*
FMS (score)	**SG**	20	2,30±1,688	5,136	,000*
	CG	20	0,00±1,076		,000*

When the table is examined, according to the pre-test and post-test results, there is a statistically significant difference in reach reach (t=4,565, p<.05), plank (t=6,778, p<.05), shuttle test (t=5,944, p<.05), FMS (t=5,136, p<.05), while there is no difference

for Y-balance test right foot (t=-1,054, p>.05), Y-balance left foot (t=0,274, p>.05). The differences found were in favor of the research group.

DISCUSSION AND CONCLUSION

The aim of this study was to determine the effect of core strength training on fms scores in tennis athletes. The mean age of the core strength group was 15,15±0,81 years, body weight 42,36±2,21 kg and height 140,25±8,41 cm. The mean age of the control group was 14,87±0,88 years, body weight was 42,63±1,96 kg and height was 138,81±7,91 cm. As a result of the independent sample t test, a statistically significant difference was found for reach and reach (t=4,565, p<.05), plank (t=6,778, p<.05), shuttle test (t=5,944, p<.05), FMS (t=5,136, p<.05), while there was no difference for Y-balance test right foot (t=-1,054, p>.05), Y-balance left foot (t=0,274, p>.05). The differences found were in favour of the research group. In the study conducted by Arı and Çolakoğlu (2021), the effects of core training programme applied in addition to technical training on strength parameters in tennis athletes were investigated. Within the scope of the study, the control group participated only in the technical training programme, while the tennis players in the experimental group participated in an 8-week core training programme. At the end of the study, it was determined that tennis players in the experimental group showed a higher increase in abdominal muscle strength, hand grip strength and lower extremity strength compared to the control group.

In the study conducted by Kara and Çelik and Kara (2021), it was aimed to investigate the effects of core training on strength performance in tennis athletes. Forty elite tennis players participated in this study. Elite tennis players in the experimental group participated in core training, while tennis players in the control group participated in the technical training model. Tennis players in both groups continued their training programmes for 12 weeks. At the end of the study, it was determined that the tennis players in the experimental group showed a higher level of improvement in push-ups, hand grip strength and back strength performances compared to the tennis players in the control group. In the study conducted by Eren (2019), it was aimed to examine the effects of core training applied in addition to the technical training programme on motor performance parameters in female and male tennis players. In this study, tennis players

in the control group participated in a technical training programme and tennis players in the experimental group participated in a core training programme. The training programmes of both groups continued for 8 weeks. At the end of the study, it was determined that vertical jump performance, which is an indicator of lower extremity strength, was higher in favour of tennis players in the core training group. In the study conducted by Doğruöz (2019) on tennis players, it was aimed to examine the effects of core training on the development of upper extremity muscle strength. In this study, which was conducted with experimental and control groups, it was found that the improvement in upper extremity strength in tennis players who participated in core stabilisation training was higher than the tennis players in the control group. In the study conducted by Çakır (2021), it was aimed to examine the effects of core training applied to athletes on physical and motor performance parameters. Within the scope of the study, 8 weeks of core training was applied to female handball players. At the end of the training programme, it was determined that there were significant improvements in leg strength, plank, back strength, push-up and sit-up performances of the athletes. In the study conducted by Tunç (2018) on tennis players, it was aimed to examine the effects of core training on the development of muscle strength. In this study conducted on tennis players in the 12-14 age group, it was determined that core training improved strength performance more compared to traditional tennis training. According to the results obtained, significant improvement was observed in both lower and upper extremity muscle strength performance in tennis players in the core training group. In Eren's (2019) study, the effects of core training applied in addition to the technical training programme on the motor performance components of male and female tennis players were examined. In the study, tennis players in the control group participated in the technical training programme and tennis players in the experimental group participated in the core training programme. The training programmes of both groups continued for 8 weeks. In the study conducted by Bilici and Selçuk (2018) on female volleyball players, it was aimed to examine the effects of participation in core training on strength performance. The study was carried out on athletes aged 14-16 years. Within the scope of the study, athletes participated in 10-week core training. At the end of the study, it was determined that there was a significant increase in the lower and upper

extremity muscle strength of the athletes participating in core training, and a performance increase was also observed in the trunk muscles of the athletes. In the study conducted by Başköy (2017), it was aimed to investigate the effects of core training on upper extremity muscle strength and service throw in tennis players. Within the scope of the study, a higher level of improvement in upper extremity muscle strength was observed in tennis players who participated in core training compared to athletes who applied traditional tennis training, and it was determined that this improvement positively affected the serve throw performance. In the study conducted by Kır (2017), it was aimed to investigate the effects of core training on the development of strength performance in young tennis players. Within the scope of the study, tennis players in the control group performed technical tennis training according to the traditional training model, while tennis players in the experimental group participated in core training. The trainings applied by both groups continued for 10 weeks. At the end of the study, it was determined that there were significant differences in squat jump and vertical jump performances, which are indicators of lower extremity strength, in favour of the tennis players in the core training group. In the study conducted by Söğüt (2009), the effects of core training on tennis-related performance parameters in male and female tennis players were investigated. Fourteen tennis players aged 13-15 years participated in the study and were included in sport-specific core training.

At the end of the study, significant increases were found in the lower and upper extremity strength performances of tennis players when compared with the performance tests taken before core training. In the study conducted by Gür (2015), the effect of core training on strength performance in tennis players and the effects of strength increase in core muscles on balance performance in athletes were investigated. As a result of the research, it was determined that core training supported the increase in strength in core muscles and this increase increased dynamic and static balance performance in tennis players. In the study conducted by Çalışkan (2014), the effects of lower and upper extremity strength training on strength performance of tennis players were investigated.

In the study, it was determined that tennis players who participated in upper and lower extremity strength training had a greater increase in sit-up and upper extremity muscle strength compared to the group that applied traditional tennis training.

Shinkle and friends (2012) examined the effect of core training on strength performance in football players. As a result of the study, significant increases in lower extremity muscle strength performance and push-up performance were observed in athletes participating in core training. In various studies in the literature, it has been reported that different training models increase strength development in tennis players. These studies support that applying core training or different strength development programmes in addition to technical skill training can improve strength performance (Sannicandro et al., 2014; Fernandez-Fernandez et al., 2016).

In tennis, serving is a critical part of the game and having a powerful serve gives the player a significant advantage (Fernández-Fernández, 2016). A maximised serve is associated with a powerful movement and the quality of the kinetic chain that performs this movement (Urartu, 1996). When looking at the kinematics of the serve, body stabilisation, lumbopelvic and core regions play an important role in the serve and help to effectively perform the movements inherent in the serve by providing power development, distal mobilisation and proximal stabilisation (Kovacs & Ellenbecker, 2011). In addition, a good level of body stabilisation helps to reduce the risk of possible injuries (Hibbs et al., 2008). In a study conducted by Başköy in 2018, 24 tennis players between the ages of 12 and 19 were firstly subjected to anterior and lateral abdominal strength tests and tests evaluating the angular velocities of the lower and upper body, and the racket speed values in contact with the ball were recorded. Then, the athletes participated in a lumbo-pelvic stabilisation training programme consisting of 5 levels and lasting 5 weeks. At the end of the training programme, the athletes were again administered the pre-tests. The results showed that at the end of the lumbo-pelvic stabilisation training, the athletes showed an increase in the tests and supported the idea that it positively affected the service speed by increasing the contact speed of the racket with the ball (Başköy, 2018).

In another study, 24 female handball players with an average age of 16 were divided into two groups, a study group of 14 and a control group of 10. Both groups were asked to shoot from a distance of 7 meters and their shooting speeds were measured. The study group practiced core training twice a week for 6 weeks. This training focused on the stability of the rotational position of the body along with basic

core practices. After the core training, the firing rates were measured again and no change was observed in the control group, while the mean firing rate of the study group increased. The results of the study indicated that the lumbo-pelvic region may affect performance by contributing to the rotational velocity of the body and that core stabilization training may have an effect of increasing the firing rate (Saeterbakken et al., 2011).

Okada et al. included 28 male and 28 female participants with a mean age of 24.4 years, who practiced various sports as a hobby and had no injury problems. The aim of the study was to investigate the relationship between core stabilization and functional movement analysis test. However, no correlation was found between core stabilization and functional movement analysis test. One interpretation suggested that people with a strong core musculature may score low on the functional movement analysis test and people with a weak core stabilization structure may do well on the functional movement analysis test. Another interpretation stated that the explanation of the relationship between performance and functional movement analysis and core stabilization is complex (Okada et al., 2011). In their study, Chorba and colleagues (2010) suggested that Functional Movement Analysis (FMA) can be used to predict injury based on a larger sample, including female athletes in sports where the upper extremity is used more intensively. They also stated that FMS may function as a predisposing factor for injury in women. Kiesel and colleagues (2007) found that lower FMS scores predicted significantly higher injury risk in professional soccer players. This study was one of the first to explore the possible predictive value of FMS. The value of this screening test was quickly recognized and widely adopted in major organizations such as the National Football League.

Recommendations

- Adding research examining the effects of core training on the technical skills of tennis players,
- Increasing studies on technical parameters such as service hit rate, service speed, forehand and backhand hitting performance,
- It is recommended to examine performance changes across different age groups and during preparation and competition periods.

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INVESTIGATION OF THE EFFECTS ON PHYSIOLOGICAL PARAMETERS OF FOOTBALL PLAYERS IN PRE-SEASON PERIOD

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Abstract
Purpose. The pre-season period in football is of great importance in order to optimise the performance of athletes and minimise the risk of injury. The aim of this study was to follow the physiological parameters of the athletes in the first pre-season preparation phase and to determine their readiness levels. Material and Methods. Twenty-four professional licensed athletes aged between 18-35 (24.3±5.42) years participated in the study. The body weight and height of the athletes at the beginning of the season were 72.4±7.44 and 180.0±6.33, respectively. At the beginning and at the end of the first preparation phase, fat measurement, squat jump, overhead squat assessment and yo-yo endurance test were performed. Results. The fat percentage obtained as a result of the tests was 7.43±0.73 in the pre-test and 6.99±0.65 in the post-test, 40.25±4.9 in the squat jump pre-test and 41.45±4.8 in the post-test, 17.33±3.5 in the overhead squat assessment pre-test and 19.50±2.1 in the post-test and 1723.3±307.6 in the squat jump pre-test and 1852.08±335.8 in the post-test. According to t-test data, statistically significant differences were found in fat percentage, squat jump, overhead squat evaluation and yoyo data (<.001). Conclusions. According to the results of the study, it can be said that the fat percentage, strength assessment, anaerobic power and endurance skills of the athletes improved in the first pre-season preparation phase.

Keywords: Football, pre-season, squat jump, overhead squat, endurance.

INTRODUCTION

The pre-season preparation period in football is of great importance in order to optimise athletes' performance and minimise the risk of injury (Bangsbo 1994). In this process, the focus is on the development of basic physiological parameters such as endurance, strength, speed and flexibility. Increasing aerobic capacity enables footballers to play at high tempo throughout the match, while improving anaerobic performance is decisive in sudden accelerations, sprints and changes of direction (Bansgbo et al., 2006). While an increase in VO_2max values is observed with the training, the improvement of muscular endurance and explosive strength increases the

effectiveness of the match in both offensive and defensive aspects (Impellizeier et al., 2006). At the same time, the preparation period reduces the risk of injury by supporting musculoskeletal adaptations. The endurance of muscle-tendon structures increases through flexibility, mobility and strength training.

Interval training, which is frequently used in this period, delays the fatigue period by increasing the lactate threshold while improving oxygen utilisation capacity (Kelly and Dust 2009). Changes in body composition such as decreased fat and increased muscle mass are other positive outcomes of pre-season training. Furthermore, thanks to adaptations in the cardiovascular system, the heart rate decreases and athletes can perform high performance with a lower pulse rate (Rampinini et al., 2007). As a result, the pre-season preparation period enables football players to reach their peak performance by improving both physiological endurance and motor skills. The balanced development of these parameters through a systematic training programme allows athletes to make a strong start to the season and achieve sustainable success (Stolen et al., 2005).

The aim of this study was to investigate the physical and physiological performance data of a professional football club in the general preparation phase before the season.

METHOD

Research Model

Male football players between the ages of 18-35 (24.3±5.42) playing in a professional football club constituted the population of the study; 24 male football players with a training age of at least 5 years, participating in national and international competitions, without any disease or injury, regularly training and competing in the professional league category constituted the sample of this study. The study design and possible risks were explained to the participants and a written consent form was filled out. In order to eliminate the learning effect on the test results, a 'familiarisation session' was first performed so that the athletes could get used to the test equipment, test protocols and the investigators. For example, a brief demonstration of how to perform the overhead squat test was given and participants were asked to perform at least 2

attempts (Engquist et al., 2015). Among the procedures for data collection, all ethical research care was taken, following the ethical principles of Helsinki 2008.

Inclusion criteria: Athletes with a regular training history of at least 5 years, training at least 5 days a week for at least 60 minutes, participating in national or international competitions, not having a serious injury in the last 6 months, not using regularly alcohol and medication were selected.

Exclusion criteria: Participants who had less than 5 weekly training sessions, consumed alcohol and regular medication were excluded.

Height, mass, body composition measurements

The height of the athletes was measured in cm with Mesilife (MC-210, Turkey) brand device. Body mass (kg), body mass index (BMI, kg/m2) and fat percentage (%) of the athletes were measured with Tanita (BC418, Japan) device by taking an upright position on the platform with bare feet and wearing only shorts and t-shirt.

Y Balance Test

The overhead squat assessment is a dynamic posture assessment that combines shoulder flexion with squatting (sitting to standing). It aims to assess whole body neuromuscular efficiency as well as dynamic flexibility, core strength and balance. Shoulder, lumbo/hip/pelvic, knee and ankle mobilisations were individually observed and angles were noted. The participants repeated the movement 2 times and the scores obtained from each region were noted as overall scores.

Squat jump

For squat jumps, participants were instructed to assume a squatting stance on a force platform (Witty, Italy) and to clasp their hands slightly behind their head to control arm support. Participants were instructed to jump continuously, as explosively as possible, as high as possible for the desired repetitions. Participants repeated the test 2 times and their best times were recorded.

Yoyo endurance test

The Yoyo test is a physical fitness test that measures endurance and fitness. Especially popular among athletes, it is used to assess running endurance and speed. The test involves the participant running forwards and backwards along a line and takes place at certain intervals at increasing speeds. The participant starts at one end of a line

and runs towards a target at the other end. Then, as soon as he/she reaches the target, he/she turns back and this process is repeated at a certain speed. The speed is indicated by audible signals and the speed increases each time. If the participant fails to reach the target or does not align with the signal sound, the test ends and the last level run is recorded (Thomas et al., 2006).

Statistical analysis

Basic central and dispersion parameters (Mean, SD, Mean Difference, CI difference 95%) were calculated for each variable. The Kolmogorov-Smirnov test was applied to confirm normality ($p>0.05$). The data were analyzed using an independent student's T- test and statistical significance was set at level $p<0.01$. SPSS 25 package programme (SPSS Inc., Chicago, IL, USA) was used for statistical analysis of the data.

RESULTS

Table 1. Descriptive statistics of participants

Variables	N	Mean±Sd	Minimum	Maximum
Height (cm)	24	180.8±6.33	165	189
Body weight (kg)	24	72.4±7.44	60.2	91.0
Age (year)	24	24.3±5.42	5	31

Values are expressed as means ± standard deviations. According to Table 1, the age of the participants was 24.3±5.42 years and the height measurement was 180.8±6.33. Body weight index were 72.4±7.44, respectively.

Table 2. Changes in the variables of the particapants before and after the tests.

Variables	N	Mean±Sd	Median	SE
Body Fat (pre)	24	7.4±0.7	7.5	0.15
Body Fat (post)	24	6.9±0.6	6.95	0.13
Squat jump (pre)	24	40.3±4.9	39.5	0.99
Squat (post)	24	41.5±4.8	41.2	0.97
Overhead Squat (pre)	24	17.3±3.5	16.5	0.71
Overhead Squat (post)	24	19.5±2.1	20	0.43
Yo-yo (pre)	24	1723.3±307.6	1760	62.78
Yo-yo (post)	24	1852.1±335.8	1845	68.55

Values are expressed as means ± standard deviations. When Table 2 is analysed, fat percentage pre-test 7.43±0.73, post-test 6.99±0.65, squat jump pre-test 40.25±4.9,

post-test 41.45±4.8, overhead squat assessment pre-test 17.33±3.5, post-test 19.50±2.1 and yoyo pre-test 1723.3±307.6, post-test 1852.08±335.8 were found.

Table 3. T-Test results

Variables	T	p-Value
Body Fat	7.46	0.000*
Squat jump	-4.65	0.000*
Overhead Squat	-5.72	0.104
Yo-yo	-4.51	0.000*

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$; mean ± standard error of the mean, N: number of participants. According to t-test data, statistically significant differences were found in fat percentage (7.46), squat jump (-4.65), overhead squat evaluation (-5.72), and yoyo (-451) (<.001).

DISCUSSION

According to the results obtained as a result of the study, fat percentage pre-test 7.43±0.73, post-test 6.99±0.65, squat jump pre-test 40.25±4.9, post-test 41.45±4.8, overhead squat evaluation pre-test 17.33±3.5, post-test 19.50±2.1 and yoyo pre-test 1723.3±307.6, post-test 1852.08±335.8 were found. According to t-test data, statistically significant differences were found in fat percentage, squat jump, overhead squat evaluation and yoyo data (<.001). The pre-season preparation period is a critical period to improve the physical capacity of athletes and to eliminate deficiencies. Various performance and movement assessment tests used in this period provide data to optimise both individual and team performance. Squat jump, overhead squat and Yo-Yo tests are three basic tests that are frequently used in football training and focus on measuring different physiological parameters. Although each test has different purposes and advantages, when used together they allow for a more comprehensive analysis of the athletes' fitness level.

When the literature is analysed, it is known that athletes have different levels of pre-season readiness. For this reason, it is aimed to bring the physiological levels of the athletes to the same ratio in the 1st preparation period of the training plans. It is known that athletes have high body fat ratios in the tests performed before the season and these ratios start to change with the preparation period. This change in body fat ratios can be

attributed to high fat oxidation due to aerobic exercises and oxidative capacity. In our study, results supporting this conclusion were obtained (7.46)(<.001).

Endurance tests are commonly used to assess the aerobic and anaerobic endurance of footballers. In this test, athletes run certain distances at gradually increasing speeds and take short rest periods after each set. The test is valuable for measuring the repetitive sprinting ability required by football matches. Footballers who obtain high scores in the Yo-Yo test can play at a high tempo throughout the match and show signs of fatigue later. Kartal and Günay (1994) found 53.05 ml/kg/min in the pre-test and 55.62 ml/kg/min in the post-test and found a statistically significant difference. İşleyen stated in his study that there was a significant difference in pre-season preparation studies. Helgerud et al. reported a significant increase in Vo2max levels. There are studies supporting these in the literature. The studies conducted by Raven et al, Filaire et al, Zizis (2013), Chin et al emphasise the development of endurance. It is in parallel with and supports the results obtained in our study.

The overhead squat analyses disturbances in movement patterns, joint mobility and postural stability. Since this test requires coordination of the shoulder, hip, knee and ankle joints, it assesses the flexibility and balance skills of footballers. It is important for footballers to have optimal movement capacity in order to minimise the risk of injury. For example, deficiencies in hip and ankle mobility can lead to difficulties during sprinting or knee injuries. Squat jump test provides important information about the explosive power of athletes. Uğraş et al. reported a significant increase in leg strength, jumping and flexibility outcomes according to physical performance data as a result of a 10-week preparation programme. Whitley et al. reported an increase as a result of a 10-week pre-season training plan. According to the findings obtained in our study, it can be clearly stated that there is a significant increase in squat jump and strength data and it is in parallel with the literature.

CONCLUSIONS

Squat jump, overhead squat and Yo-Yo tests are important tools to comprehensively assess the physical performance of footballers during pre-season preparation. Each test provides information about the strength, mobility and endurance

levels of football players by focusing on different physiological parameters. Individualised training programmes based on the test results help athletes to improve their deficiencies and reduce the risk of injury. This approach allows for the creation of a team structure that performs well at the beginning of the season and maintains its form throughout.

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SEVERE PEDIATRIC SEPSIS CAUSED BY NEISSERIA MENINGITIDIS: A CASE REPORT

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Abstract

The aim is to report on the aggressive nature of Neisseria meningitidis infection among children and its complications.

Case report: We present the case of a 2-month-old infant who was admitted for fever, diarrhea, moaning, and appetite loss to the Emergency Clinical Hospital for Children "Sf. Ioan" Galați. The infant was admitted to the intensive care unit and underwent clinical evaluation along with extended laboratory investigations. Neurological manifestations began on the first day of hospitalization, starting with tonic seizures. Later, anisocoria and ptosis of the left eye developed over the following days. On the 4th day of hospitalization, positive blood culture for Neisseria meningitidis was obtained and the second blood culture turned out negative. Antibiotic treatment was initiated, and multidisciplinary consultations were conducted to address the ensuing complications.

Discussion: The case highlights the severity of Neisseria meningitidis infection in infants and the rapid progression to neurological symptoms, often accompanied by serious complications. Early management through appropriate antibiotic therapy, aided by a multidisciplinary approach, is essential to limit mortality and sequelae.

Conclusion: Neisseria meningitidis is the cause of serious infections with a high mortality rate and neurological sequelae. The complexity of such cases requires multidisciplinary intervention.

Keywords: child, sepsis, Neisseria meningitidis, complications.

INTRODUCTION

Neisseria meningitidis is an aerobic, Gram-negative diplococcus bacterium commonly known as meningococcus. The most prevalent serogroups are A, B, C, W, X, and Y, distinguished by the type of polysaccharide capsule and are responsible for infections in the general population (2). The majority of cases occur in the pediatric

population, particularly in children under 5 years of age (11). It most commonly occurs with the serogroup B, according to the European Centre for Disease Prevention and Control (3). A variety of laboratory analyses, including blood cultures, can be used to identify the bacterium.

Infections caused by this bacterium are highly aggressive and require urgent therapeutic intervention, with a mortality rate of 4% to 20% within the first two days post-infection (14, 15). The most common conditions include meningococcal meningitis and meningococcal sepsis (12, 13). Post-infection, approximately 10–20% of cases result in sequelae such as behavioral changes, hearing loss, oculomotor impairment, or limb amputations (9).

The septic shock caused by *Neisseria meningitidis* results in aggressive inflammatory responses and coagulation issues that, if not localized, will lead to death quickly. In contrast, meningococcal meningitis accounts for approximately 80% of reported cases (4).

The rate of meningococcal infections has decreased in developed countries due to prophylaxis with conjugate vaccines covering serogroups A, C, W, and Y, as well as monovalent vaccines for serogroup B (7).

Case presentation

A 2-month-old male infant, firstborn via C-section at 38 weeks, with a history of difficult postpartum respiratory adaptation requiring oxygen support at birth, was admitted to the Intensive Care Unit of the Emergency Hospital for Children 'Sf. Ioan' in Galati after being transferred from a secondary hospital. The onset of symptoms, which began a day prior to hospitalization, included fever (T=38.7°C), four episodes of diarrhea, moaning, and loss of appetite.

Family medical history: Mother with pregnancy-induced hypertension.

First clinical examination:

Weight: 6000 g. The infant presented in a severe clinical condition, afebrile at the time of consultation, with extremely pale and mottled skin, a capillary refill time of 4 seconds, moaning, and a depressed fontanel. The heart was rhythmic and well-perfused, with a cardiac rate of 110 bpm and blood pressure of 102/54 mmHg. The

respiratory rate was 35/min, and blood oxygen saturation ranged between 97-100%. The abdomen was bloated, diuresis was observed in the diaper, and the pupils were symmetrically reactive.

The first biological samples reveal the following findings: pancytopenia (leukocytopenia, erythrocytopenia, thrombocytopenia), low hemoglobin levels, an altered coagulogram with elevated INR, PT, APTT, and D-dimer values. Additionally, there are raised levels of C-reactive protein (12.83 mg/dL) and procalcitonin (14.7 ng/mL). Glucose, albumin, calcium, sodium, and iron levels are low. Metabolic acidosis and elevated indirect bilirubin levels are also noted. A blood culture has been collected.

Based on the clinical examination and supported by biological findings, the clinical suspicion is sepsis and disseminated intravascular coagulation (DIC).

On the first day in the hospital, broad-spectrum antibiotic treatment with intravenous Ceftriaxone was initiated. However, due to clotting disorders and elevated inflammatory markers, the treatment was escalated to i.v. Meropenem and Linezolid.

It was also supplemented with human immunoglobulin intravenous, antifungal treatment intravenous., isoRh and isogroup resuspended erythrocyte concentrates, isoRh and isogroup fresh frozen plasma, diuretics, and infusions for hydro-electrolytic and acid-base rebalancing.

On the first day of hospitalization, the patient associates tonic clonic seizure with nystagmus with a capped gaze and eyeball deviation, managed with intravenous Levetiracetam.

On the second day of hospitalization, clinical examination revealed: an extremely severe general condition, subfebrile state, and extreme agitation with continuous moaning. The skin appeared very pale and mottled, with a capillary refill time of 4 seconds. A grade II/VI systolic murmur was detected, with a cardiac frequency of 130 bpm and blood pressure of 98/75/79 mmHg. Blood oxygen saturation was 93%, with evident chest-abdominal swings. Diuresis was 2.9 mL/kg/h. The anterior fontanel was tense, and the pupils were slow to react.

First transfontanellar ultrasound: non dilated ventricular system with mild asymmetry.

The neurological examination reveals the following findings: extremely severe clinical condition, tense anterior fontanel, absent reflexes, and frowning. Clinical suspicions include sepsis, encephalitis, and febrile seizures. Continue treatment with intravenous Levetiracetam and add oral Phenobarbital, intravenous glucocorticoids, and intravenous mucolytics.

On the 4th day of hospitalization, the patient remains in an extremely severe condition, presenting with hypertonia, edema of the lower limbs and scrotum, and anisocoria (left pupil larger than the right). A second transfontanelar ultrasound is performed, revealing: asymmetry of the bilateral fronto-parietal subarachnoid space, a left fronto-parietal hypoechoic-transonic collection, with a maximum thickness of 16 mm. It maintains ventricular asymmetry, with a slightly inhomogeneous aspect of the right frontal horn. A cranial CT scan was performed to provide greater diagnostic precision. The imaging revealed dilated pericerebral fluid spaces and asymmetry at the frontal level. Additionally, a subdural hypodense collection with a maximum thickness of 18 mm was identified, along with parafluid densities in the pericerebral fluid spaces.

On the 5th day of hospitalization, the blood culture results indicate a positive finding for Neisseria meningitidis. The pathogen is found to be susceptible to Cefuroxime, Ceftriaxone, Meropenem, Rifampicin, Trimethoprim-Sulfamethoxazole, and Chloramphenicol. Based on these findings, it is decided to reintroduce treatment with Ceftriaxone. Clinically, the patient mentains extremely severe conditions associated with palpebral edema.

The neurosurgical examination reveals a somnolent patient who is poorly responsive, does not open his eyes, and exhibits spontaneous symmetric limb movements of low amplitude. The recommendation is to perform a brain MRI with contrast for further evaluation.

6^{th} day in hospital: The brain MRI reveals left extranevraxial fluid accumulation with an appearance suggestive of a hydroma. No evidence of empyema or hemorrhage is observed. Upon re-examination by the neurologist, the patient is noted to have no seizures but continues to exhibit palpebral edema of the left eye and eyeball deviation.

Based on these findings, it is decided to reduce the doses of Phenobarbital and

Acetazolamide and to switch the mode of administration of Levetiracetam from intravenous to oral.

8th day in hospital: transfontanellar ultrasound with stationary appearance comparative to previous examination.

14th day in hospital: MRI re-evaluation stationary appearance comparative with previous examination.

The patient demonstrates a progressive and favorable clinical course, with no further seizures. Given the improvement in laboratory findings under antibiotic treatment, the patient is discharged on the 22nd day. The discharge plan includes continued oral antiepileptic treatment with Phenobarbital and Levetiracetam, as well as scheduled neurological and ophthalmological re-evaluations during the recovery period.

Table 1. Succesive characteristics of biological data

Biological analysis	1st day	2nd day	6th day	15th day	20th day
Hemoleucogram	Leukopenia, erhitrocytopenia, thrombocytopenia, Low Hemoglobin	thrombocytopenia	Leukocytosis, erhitrocytopenia, Low Hemoglobin	Leukocytosis, thrombocytosis	Thrombocytosis,
Coagulation	D-dimers, INR, APTT, PT ↑	D-dimers,PT, INR↑	D-dimers, INR↑	D-dimers ↑ APTT ↓	N
C-reactive Protein	12,83mg/dl	23,67 mg/dl	4,41 mg/dl	24,57mg/dl	<0,5mg/dl
Procalcitonin	14,7ng/ml	16,2ng/ml	0,508 ng/ml	7,81ng/ml	N
Transaminase	N	N	N	N	N
ESR	N		↑	↑	
LDH	N	↑	N	↓	N
CK	N	N	N	N	N
Glucose	66,6 mg/dl	N	N	N	N
Iron	12 mcg/dl				
Ionogram	Na↓	N	N		N
Immunogram	IgA,IgG↓				
Albumin	↓	↓	↓	↓	
Bilirubin	IB ↑	IB, DB↑	N	N	

DISCUSSION

Sepsis due to *Neisseria meningitidis* is an infection that is rapidly progressive and life-threatening in infants and young children. This bacterium indeed causes meningococcal meningitis and sepsis, two of the most severe infections of the pediatric population. Clinical manifestations can escalate very fast, leading to shock, failure of organs, and neurological complications that are serious. As in the case of the 2-month-old infant presented, early diagnosis and early aggressive treatment are critical. The clinical deterioration in the form of tonic seizures, anisocoria, and subdural hygroma points toward the continuous monitoring and a multidisciplinary approach such patients need.

The diagnosis of meningococcal sepsis is an integrated analysis of clinical suspicion, laboratory tests, and imaging studies. Blood cultures, as in the case presented, are a very important part in the recognition of the pathogen, while imaging techniques such as cranial CT and MRI are really necessary in the assessment for neurological complications like brain edema or subdural fluid collections. The development of evolving neurological symptoms in the patient, such as anisocoria and ptosis, further underlines the seriousness of the infection with its long-term sequelae of cognitive and motor impairments (10). Antibiotic treatment should be given according to the antibiotic susceptibility profile of *Neisseria meningitidis* to control the infection. In this case, the stepwise escalation from ceftriaxone to meropenem and linezolid, with a return to ceftriaxone once the pathogen was confirmed, represents an approach to optimization.

As common with sepsis induced by *Neisseria meningitidis*, DIC often follows in suit, and indeed, this case exhibited similar trends. This was a serious complication characterized by widespread clotting and bleeding, resulting from an excessively activated coagulation system. This condition significantly contributed to the sudden clinical deterioration observed in this patient. Such conditions require careful management with anticoagulation as supportive therapy to counteract the hypercoagulable state, along with fluid resuscitation and transfusions to address clotting factor deficiencies and maintain hemodynamic stability during treatment (5). In pediatric cases, DIC is associated with a higher mortality rate, making early recognition

and treatment vital. This is consistent with the findings from several studies which demonstrate that early intervention in sepsis, particularly in infants, can significantly reduce mortality and long-term disability (1).

The role of vaccination in preventing *Neisseria meningitidis* infections is something that cannot be denied. Vaccination has clearly been the major driving factor for a reduction in invasive meningococcal disease in many countries. These have involved conjugate vaccines against serogroups A, C, W, and Y and a monovalent vaccine for serogroup B; the number of cases has drastically declined since then (6).

These vaccines stimulate the immune response to produce antibodies against these serogroups, thereby preventing primary infections and hence their serious complications. The very low incidence of meningococcal infection in the developed world illustrates the efficacy of vaccination programs in controlling disease burden and averting life-threatening conditions (8).

CONCLUSION

This case of an infant demonstrates the fulminant course of *Neisseria meningitidis* infection with rapid neurological and systemic complications, disseminated intravascular coagulation, including tonic seizures, subdural hygroma, ventricular asymmetry, and anemia. Successful management was performed based on a multidisciplinary approach: early diagnosis by paraclinical investigations, appropriate antibiotic therapy, anticonvulsant treatment, and supportive care. This again highlights early intervention and close follow-up as key factors to decrease complications and mortality, along with improving the long-term outcome in severe pediatric sepsis.

Abbreviations:

INR- international normalized ratio

PT-prothrombin time

APTT- activated partial thromboplastin time

ESR- erythrocyte sedimentation rate

LDH- lactate dehydrogenase

CK-creatine kinase

CT- computerized tomography scan

MRI- magnetic resonance imaging

DIC- disseminated intravascular coagulation

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ROLE OF IMAGING INVESTIGATIONS IN DETECTING THYROID NODULE MALIGNANCY. A RETROSPECTIVE STUDY

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Abstract

Nodular thyroid pathology is a topical public health problem that is increasingly targeted and discussed by the general population. The prevalence is around 10%, but rates up to 68% are reported in the literature. In Romania, according to statistics from the National Institute of Public Health, the incidence of thyroid diseases has tripled between 2010 and 2016 and is increasing, which can also be explained by improved patient access to specialized medical services and diagnostic tests. High-resolution thyroid ultrasound is deemed the preferred screening examination for the diagnosis of thyroid lumps, using the Ti-RADS system it identifies nodule types and assesses malignancy risk. Elastography is a newly introduced dynamic method applying software in ultrasound to appraise tissue rigidity by projecting distortion caused by external forces, like palpation, during thyroid evaluations in physical exams. These tests used both could improve the accuracy of diagnosis of thyroid nodules.

Keywords: Ti-RADS, Thyroidian nodules, Elastography, ultrasound.

INTRODUCTION

1. *General review of thyroid*

The thyroid gland plays an important role in regulating multiple processes in the human body such as metabolism, energy consumption, as well as heart and brain function.

The hypothalamic-pituitary axis is responsible for generation and distribution of thyroid hormones. Thyrotropin, also known as thyroid- stimulating hormone (TSH) is secreted by the anterior pituitary, stimulated by thyrotropin-releasing hormone secreted in hypothalamus.

As a feedback to TSH emission, follicular cells synthesize thyroglobulin, an non-active protein, which reacts like a colloid moving from the surface into the follicles.

Levothyroxine serves as the primary thyroid secretion and is also called thyroid hormone. It is the product of two tyrosine molecules, each binding two Iodine molecules. The main function of this hormone is to incorporate, concentrate and store Iodine molecules in the circulation even against a concentration gradient.

The main transporter is the NIS (Na-Iodine symporter), which is located in the basement membrane of thyroid cells and has the function of transporting inorganic iodine to thyroid cells, as shown in Figure 1. As a result of this process, the iodine concentration in thyroid cells increases about 20-40 times that in the blood. Once in the cell, iodine becomes organic and is incorporated on tyrosine residues present on the amino acid sequence of thyroglobulin. This process occurs at the apical membrane of the thyroid cell and is supported by thyroidperoxidase (TPO) in the presence of hydrogen hydroxide, pendrin and possibly the calcium-activated anionic membrane channel anoctamine 1. [27]

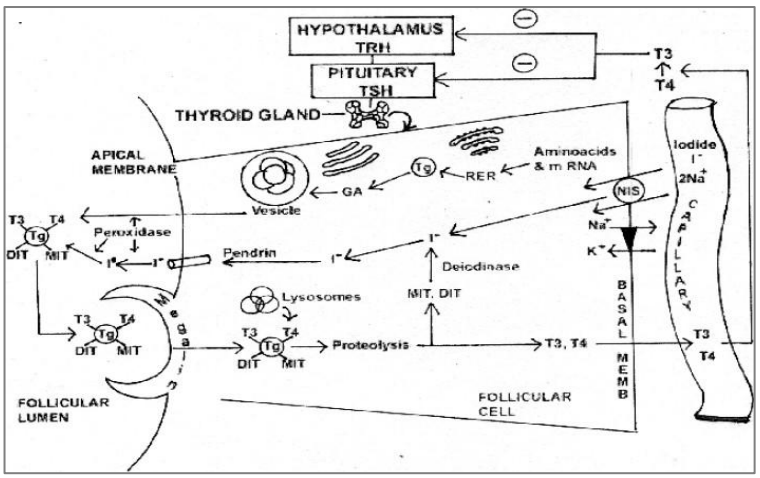

Figure 1. *Synthesis and Release of thyroid hormones [Khurana I. Textbook of Medical Physiology. India: Reed Elsevier; 2006. Endocrinal System; pp. 710–715.]*

Under the influence of TSH- via the process of pinocytosis the thyroglobulin in the colloid enters the thyroid cell, where it is destroyed by endopeptidase, so that the thyroid hormone that is incorporated into its amino acid is released into the circulation as levothyroxine.

Thyroid hormones circulate in the bloodstream bound predominantly to the thyroxine-binding protein.[5]

2. *Thyroidian nodules*

According to American Thyroid Association (ATA), thyroidian nodules are characterized as "separate lesions of the thyroid , radiologically clear from the surrounding thyroid parenchyma". They may be incidentally detected through palpation during a routine physical examination or during imagistic investigations performed for routine evaluations such as carotid duplex ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI), or ^{18}F- fluorodeoxyglucose positron emission tomography (18FDG- PET).

While approximately 7-15% of thyroid nodules are malignant; [36] the rest of cases are represented by benign masses (**Table 1**). An effective approach on management of nodular tissue depends on the clinician's aptitude to differentiate a malignant nodule from a benign one with high accuracy and without additional costs.

Table I. The classification of thyroid nodules

Benign thyroid nodules	**Malignant thyroid nodules**
Multinodular goiter - colloid nodule	Papillary carcinomas
Hashimoto's thyroiditis with nodularization	Follicular carcinomas
Colloid cysts, simple or hemorrhagic	Anaplastic/differentiated carcinomas
Follicular adenomas	Medullary carcinomas
Hürthle cell adenomas	Primary thyroid lymphomas
	Metastatic carcinomas

Etiologically, thyroid nodular disease can be caused by exposure to ionizing radiation. According to studies, ionizing radiation is a well-established risk factor for benign as well as to malignant thyroid nodules. The thyroid nodules can occur at an annual rate of 2% of exposed population. [34] Smoking, obesity, obesity, metabolic syndrome, alcohol consumption, elevated levels of insulin-like growth factor-1 and uterine fibroids are also risk factors for thyroid nodular disease. [36]

2.1.Epidemiology of thyroid nodules

Nodular thyroid disease is a pathology with a higher prevalence among female patients, this aspect is also confirmed in specialized studies, thus, in the Framingam study conducted on a group of 5234 patients over 60 years of age, a female prevalence of 6.4% was found, while men had a ratio of 1.5%. [32] Another study by Tunbridge claims that nodular thyroid disease is prevalent in females with a female:male ratio of 4:1, [31] this radio is explained by the hormonal influences.

The most important challenge in thyroid nodular disease is the correct identification of cancer cases, which occur in 7–15% of all thyroid nodules.[25, 22] The occurrence of both thyroid nodules and thyroid cancer has risen significantly in recent years. Recent data from the United States shows about 63,000 new thyroid cancer cases annually. This rise is largely attributed to early detection through high-resolution ultrasound and the identification of subclinical thyroid nodules.[36] Another theory, attributes the elevated incidence of thyroidian nodules to medical radiation exposure, iodine intake, obesity and insulin resistance, genetics and inorganic phosphates [20, 37] with a 300% increase in the annual rate of thyroid cancer. [6]

Thyroid cancer ranks 7th in the incidence of malignant pathologies worldwide according to Global Cancer Observatory, which registered 821,214 newly confirmed cases of thyroid cancer worldwide in 2022 [4] The incidence of thyroid malignancies worldwide is shown in **Figure 2**.

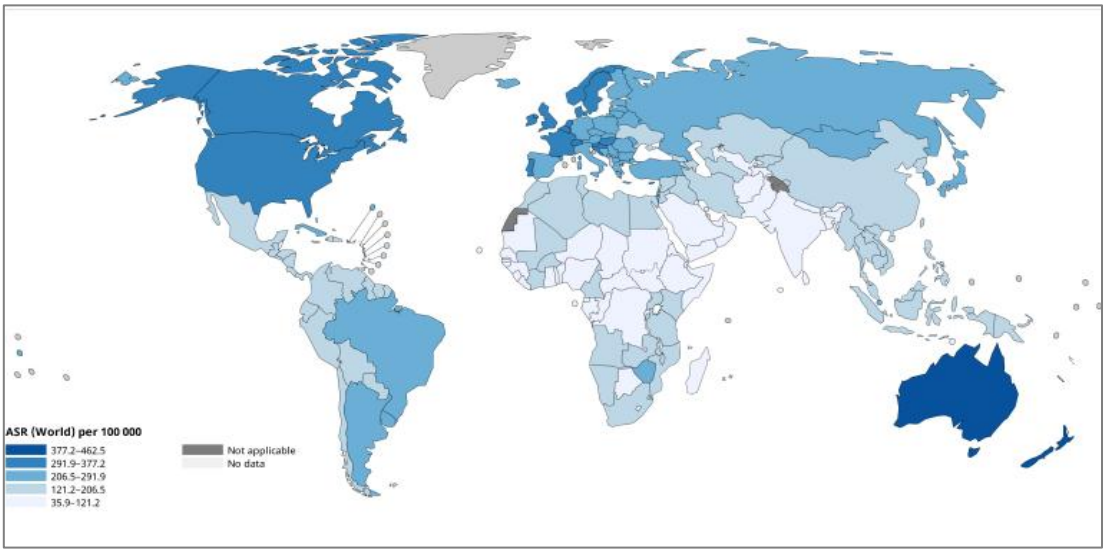

Figure 2. *The worldwide incidence of thyroidian cancer [GLOBOCAN 2022]*

According to the statistics of the International Agency for Research on Cancer, in Romania in 2022 there were 104,661 confirmed cases of thyroid malignancy, a number that places thyroid cancer on the 15th place as incidence of oncologic diseases in our country. [14]

3. Paraclinical investigations of thyroid function

Correct ordering of laboratory tests facilitates early diagnosis of a thyroid disorder and contributes to timely and appropriate treatment. The main laboratory tests for the detection of thyroid disorders are presented in the table bellow.

Table 2. Main thyroid laboratory tests and their clinical significance

Laboratory test	**Clinical significance**
TSH	- Primary screening test for thyroid dysfunction. - Evaluation of thyroid hormone replacement therapy in patients with primary hypothyroidism. - Evaluation of suppressive therapy in patients with follicular cell derived thyroid cancer.
T4	- Detection of thyroid dysfunction in association with TSH. - Evaluation of thyroid hormone replacement therapy in patients with secondary hypothyroidism (free T4). - Evaluation of thyroid dysfunction in pregnancy (total T4).
T3	- Detecting hyperthyroidism - Not useful in the management of hypothyroidism. - May be useful in diagnosing nonthyroid diseases.
Thyroidian antibodies	- Positive in autoimmune thyroid disease. - TPOAb - evaluation of patients with subclinical hypothyroidism and women with recurrent miscarriages. - TRAb - diagnosis of Graves' disease; aids in predicting Graves' patients who may be weaned from antithyroid drugs.
Tireoglobulin	- Evaluating the effectiveness of treatment for differentiated thyroid cancer and monitoring residual or recurrent disease. - Diagnosis of thyrotoxicosis.
Calcitonin	- To diagnose medullary thyroid cancer and to monitor recurrence, progression and response to treatment.

4. Imagistic tests of thyroid gland

The gold-standard imaging methods to explore the thyroid gland are:

- High-resolution ultrasound;
- Elastography;
- Scintigraphy.

High-resolution ultrasound

High-resolution ultrasonography (USG) is the most accurate imaging technique currently available for evaluating the thyroid gland and its associated conditions. The benefits of ultrasound scanning include non-invasivity, accesibility, cost-effectivenes and it is free from ionizing radiation. Further, real time ultrasound imaging is useful in guidance diagnostic and therapeutic interventional procedures in cases of thyroid disease. The most important limitation of ultrasound in thyroid imaging is its inability to assess thyroid function, such as whether the gland is hypoactive, hyperactive, or functioning normally. This evaluation typically requires a blood test or a radioactive isotope uptake test.[29, 4]

Indications for thyroid USG, following the American Association of Clinical Endocrinologists (AACE) and Associazione Medici Endocrinologi (AME) recommendations, [9] are as follows:

- To assess the existence of a thyroid nodule when findings from the clinical examination are inconclusive.
- To define one or more thyroid nodules by accurately measuring their dimensions, assessing their internal structure, and evaluating vascularization.
- To distinguish a malignant thyroid mass from a benign one based on their sonographic characteristics.
- To distinguish a thyroid nodule from other cervical masses.
- To assess difuze changes in thyroidian parenchyma.
- To identify postoperative residuals and tumoral masses, also identifying methastases in cervical lymph nodes.
- To follow up the patients at high risk for thyroid malignancy.
- To assist in guiding diagnostic procedures and interventional techniques.

TI-RADS classification

TI-RADS, short for Thyroid Imaging Reporting and Data System, [30] is an ultrasound-based classification system designed to quantify characteristics of thyroid nodules, modeled after the ACR BI-RADS system used in breast imagistics. In 2017, the American College of Radiology (ACR) TI-RADS Committee of the American College of Radiology (ACR) introduced a new risk classification system for grouping thyroid nodules based on their appearance on ultrasonography. [30] The ultrasound features in the ACR TI-RADS are classified depending on risk of malignancy. Points are assigned based on the ultrasound features of a nodule, with more concerning features receiving higher scores. **Figure 3** displays these features organized according to the five lexicon categories. [11]

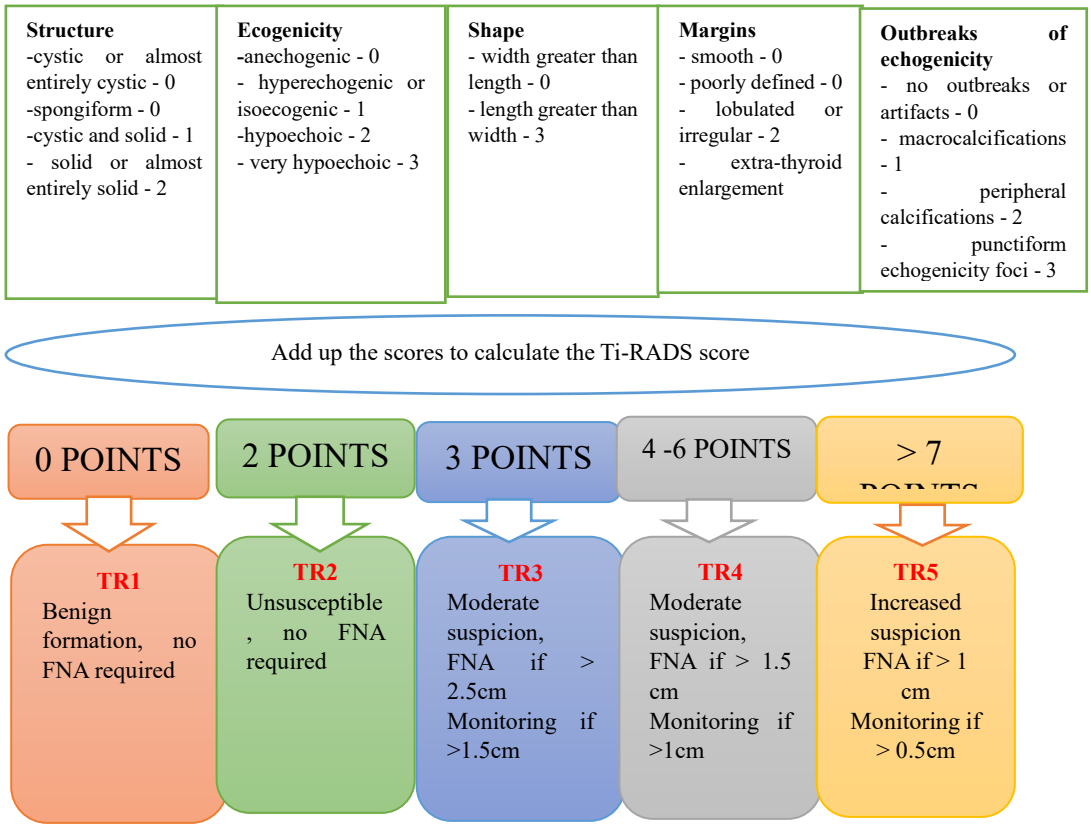

Figure 3. *Sonographic features and associated points grouped according to the five ACR TI-RADS categories*

The sum of the assigned points defines malignancy risk according to 5 grades, corresponding to low or high suspicion of malignancy. This system does not include subcategories and no TR 0 group to indicate normal thyroid.

The criteria for performing fine-needle aspiration or indication for USG monitoring are based on the final ACR TI-RADS score and the biggest nodule diameter. For risk grades including TR3 and TR5, there are established some size limits, at or above this limit is indicated performing of fine-needle aspiration. There were also established lower limits for nodules classified as TR3, TR4, TR5, that should be ultrasound monitotored, in order to reduce the number of repeated examinations for nodules which are more likely to be benign. High-risk nodules undergo biopsy only if they are 1 cm or larger, whereas low-risk nodules are further evaluated only when their size reaches 2.5 cm or greater.

The primary objective of ACR TI-RADS is to optimize the detection of clinically significant malignancies while minimizing the risks and costs associated with invasive investigation and treatment of benign nodules or indolent, non-aggressive tumors. The indications for ultrasound follow-up aim to reduce the possibility that significant lesions remain undetected over time.

Comparative studies indicate that the ACR system demonstrates a sensitivity of 75–97% and a specificity of 53–67%. It is reported to either have the highest sensitivity and lowest specificity among the compared systems [38] or, alternatively, the highest specificity.[12, 10]

Thyroidian scintigraphy

This days, the standard initial diagnostic review of a single thyroid lump no longer employs nuclear imaging methods as it was before. Nuclear imagistics are utilized to classify a nodule as warm or cold based on its relative uptake of radioactive isotopes. Hot nodules indicate independently functioning thyroid tissue, warm nodules describe normal thyroid function, and cold nodules represent hypofunctional or nonfunctional tissue. Hot nodules are infrequently malignant, while 5–8% of warm or cold nodules are associated with malignancy. [8]

The indications for this investigation are :a) Defining the functional status of the thyroid gland; b)Thyrotoxicosis, differential diagnosis; c)Thyroid cancer: whole body scanning for detection of distant metastases, estimation of local residual after thyroidectomy, follow-up for recurrence.

The results are interpreted according to the degree of uptake. Benign nodules are classified according to their ability to produce hormones compared to healthy thyroid tissue. They fall into three categories: 'warm', 'cold' and 'normal' nodules. "Warm" nodules are more active than normal thyroid tissue and therefore produce more hormones. 'Cold' nodules, on the other hand, are clumps of tissue with no real ability to produce thyroid hormones compared to normal thyroid tissue. Finally, normal nodules cannot be differentiated from healthy tissue on the basis of their hormone-producing capacity. The majority of thyroid nodules are cold nodules (about 50-85%), while only 10% of nodules are 'warm' and about 40% are 'normal'.

Thyroidian elastography

Elastography shows an elasticity score as a qualitative result and the strain ratio. Benign lesions push but do not invade the surrounding structures, they remain with normal elasticity, unlike hard malignant lesions, which infiltrate and stiffen the neighboring structures, this difference being objectified in the elastographic mode by the increased projection area of the malignant lesions, corresponding to the infiltration of the surrounding structures. Research indicates that elastography can effectively distinguish malignant thyroid nodules from benign ones with high sensitivity and specificity. [26]

Strain elastography

Strain elastograms of nodules are systematically assessed using a gradual scoring method, based on the dominant shade within the nodular tissue. The two principal scoring systems are those classified by Asteria et al. [1] and Rago et al..[26]The first one, based on the breast strain USE scale of Itoh et al..[15] All the aspects are adapted to thiroidian tissue, and evaluate qualitative features of the thyroidian lumps.

Table 3. Criterias for qualitative elastography

Rago criteria for qualitative elastography deformation elastography images.	**Asteria criteria for qualitative strain elastography images.**
Score 1: uniform soft elasticity in the whole knot; Score 2: elasticity in a large part of the knot;	Score 1: Elasticity in the whole knot; Score 2: Elasticity in most of the knot; Score 3: Stiffness in most of the knot;

Score 3: elasticity in the peripheral part of the knot; Score 4: lack of elasticity in the whole knot; Score 5: lack of elasticity of the knot and the area around the knot.	Score 4: Knot without elasticity.

The criteria followed in strain elastography are :

The criteria followed in strain elastography are:

The area ratio, in which the area of the nodule is measured and compared with the area of a surrounding thyroid tissue, three different measurements and the mean value is taken into account. [17] The described threshold value for AR suggestive for malignancy is a ratio of 1.08 with a sensitivity, specificity of 91.3, 86.6, 82.3 and 93.4%, respectively. [17]

Hard area ratio which measures the ratio of the hard area in the nodule to the entire area of the nodule, with a cut-off value of 0.6 suggestive of malignancy: 92.9% sensitivity, 91.3% specificity and 92% accuracy. [21]

Deformation ratio of the nodule to the sternocleidomastoid muscle: the muscle is considered the reference area for calculating the deformity and not the healthy thyroid tissue, with reasonable results: sensitivity 90% and specificity 50% for a cut-off value of 1.5. [16]

Strain index is a ratio of the strain of the whole nodule divided by the strain of the soft part of the nodule, with a cut-off value of 2.05.

The stiffness ratio is a special ratio calculated by Philips devices by comparing the stiffness of the lump to the surrounding apparently healthy tissue, with a cut-off value described as 3.16.

The systolic thyroid stiffness index = compares the highest stiffness near the carotid artery with the lowest stiffness in the thyroid nodule, over an area of 2 mm × 2 mm. No clear values are described.

Elasticity contrast index = technique is specific to Samsung devices - obtains a deformation oscillation map, with malignant lesions showing higher contrast than a benign lesion . The cut-off value described in the literature is between 3, 5 and 4.[3] It should be taken into account that the results are influenced by age, atherosclerosis, hypertension and tachycardia-associated conditions.

Realtime Shearwave elastography

Real-time shear wave elastography is performed like a conventional ultrasound, with a linear probe at the end of the conventional US evaluation, with the patient in apnea. The device generates both quantitative and qualitative information : color-coded color maps with the following color code: blue = soft tissue, red = hard tissue, respectively, quantitative information evaluated by the elasticity index expressed in kilopascal.[14] As in elastography strain ,in elastography shear wave over time is displayed in parallel with the gray scale of the ultrasound, with probe placement on the nodular lesion. At least three loops without transducer motion should be recorded for quantitative evaluation.

The diagnostic qualities of this type of qualitative, color-mapped elastograph generate information with a sensitivity of 95.5% and specificity of 45.7% for elasticity score II (predominantly soft), 72.7 and 84.5% for elasticity score III (elastic at the edges and stiff middle, respectively) , 54.5 and 97.4% for elasticity score IV (significantly increased stiffness).[23]

MATERIALS AND METHODS

This study is based on the anamnesis, laboratory investigations and imaging investigations of the patients enrolled in the study hospitalized in the Endocrinology Department of the County Emergency Hospital "Sfântul Apostol Andrei" of Galati in the period 2020-2022.

In this study TSH and FT4 values, which describe the thyroid hormone balance, were analyzed. The samples were collected on an empty stomach and were analyzed immunochemically in the Laboratory of the County Emergency Hospital "Sfântul Apostol Andrei", Galati.

The ultrasound scans were performed using the ESOATE MyLab X7, which has extensive configuration features. Using the same apparatus via ElaXto which is a non-invasive method for the determination of tissue elasticity, elastographic nodule formations were analyzed. Elasticity differences between tissues were detected and visualized in real time.

The study was retrospective, and attempted to establish the correlation between the results of elastography, scintigraphy, anatomic-pathologic examination and the TI-RADS score.

Data were loaded and processed using statistical functions in SPSS 18.0 at 95% significance level.

RESULTS

Clinical study: Forty female patients were included in this trial aged between 43 and 74 years, with a total number of 122 analyzed nodules. Multiple nodular formations, spread unilaterally or bilaterally, were found in most patients. The distribution of nodules is represented in the table bellow:

Table 4: The correlation of number of nodules and their localization

Localization		**NODULES**							
		1	2	3	4	5	6	N	p
RTL 1	n	4	4	18	8	2	2	38	0,143
	%	10,5	10,5	47,4	21,1	5,3	5,3	95,0	
RTL 2	n			10	8	2	2	22	**0,001**
	%			45,5	36,4	9,1	9,1	55,0	
RTL 3	n			1			2	3	**0,018**
	%			33,3			66,7	7,5	
RTL 4	n						2	2	**0,007**
	%						100	5,0	
LTL 1	n	2	4	16	8	2	2	34	**0,018**
	%	5,9	11,8	47,1	23,5	5,9	5,9	85,0	
LTL 2	n			6	8	2	2	18	**0,001**
	%			33,3	44,4	11,1	11,1	45,0	
LTL 3	n					2		2	**0,007**
	%					100		5,0	
Istm	n		3					3	0,405
	%		100					7,5	
Nr of patiens x nodules		6 x 1	4 x 2	18 x 3	8 x 4	2 x5	2 x 6	122	
		15,0	10,0	45,0	20,0	5,0	5,0	nodules	

There were analyzed echographic aspects of the nodules such as structure, echogenity, shape, margins and outbreaks of echogenity and were classified according to Ti-RADS score with the results bellow:

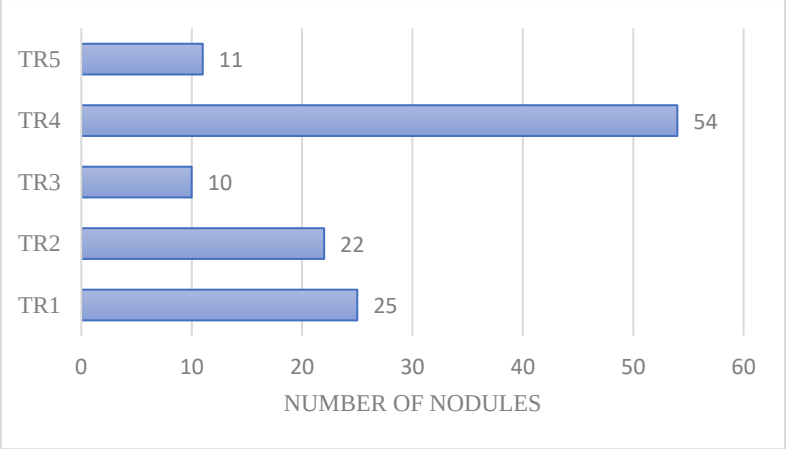

Figure 4. *The distribution of nodules by Ti-RADS score*

According to this distribution the number of nodules with the highest risk of malignity are represented by the nodules with Ti-RADS score 4 and 5, with a percentage of 44,26% respectively 9,02%.

Analyzing the elastography result, the mean hard/soft percentage was higher in the nodular formations on the LTS.

Tabel 5. Hard/soft percentage descriptive data

	LTD1	LTD2	LTD3	LTS1	LTS2	Istm
N	22	6	1	11	5	1
Average	68,64	66,67	60	83,64	48	60
Median	70	70	60	80	50	60
Standard Deviation	12,36	13,66		10,27	20,49	
Variant	18,01	20,49		12,40	42,69	
Skewness Test	-0,737	-0,523		0,448	1,022	
Std. Error of Skewness	0,491	0,845		0,661	0,913	
Minimum	50	50	60	70	30	60
Maximum	80	80	60	100	80	60

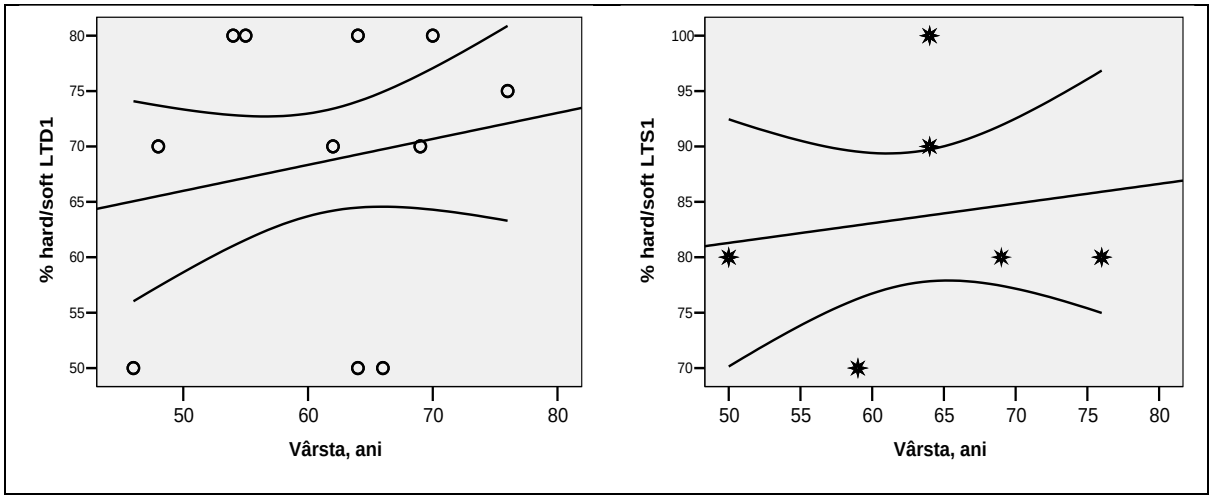

Figure 5. *Correlation between hard/soft percentage and age*

The percentage hard/soft elastography score correlated directly, but reduced in intensity with age, for both LTD (r=0.175; p=0.437) and LTS (r=0.149; p=0.661).

18 out of 40 patients underwent scintigraphy on the recommendation of the endocrinologist, which revealed 20 hypercapping areas, i.e. 'hot' formations, and 6 hypocapping, i.e. 'cold' formations.

All of the 40 patients were referred for surgery. Anatomo-pathologic examination was performed following surgery.

A total of 121 nodules were analyzed post-surgically anatomopathologically, which were categorized into benign and malignant nodules. There were identified 4 medular carcinomas, 8 folicular carcinomas and 12 papilar carcinomas and 97 benign nodules.

Depending on localization, anatomopathologic outcome did not correlate significantly with TI-RADS scores.

Table 6. Correlation of TI-RADS score with anatomopathologic findings

Localization	TiRads	Anatomo-pathology		p
		Malignant	Benign	
RTL1	TR1	12,5%	23,3%	
	TR2	12,5%	20,0%	
	TR3	12,5%	-	0,414
	TR4	50,0%	40,0%	
	TR5	12,5%	16,7%	

RTL2	TR1	-	22,4%	
	TR2	25,0%	22,4%	
	TR3	25,0%	5,6%	0,470
	TR4	50,0%	38,9%	
	TR5	-	11,1%	
RTL3	TR4	-	100%	nc
RTL4	TR1	-	100%	nc
LTL1	TR1	30,0%	20,8%	
	TR2	20,0%	33,3%	
	TR3	10,0%	8,3%	0,865
	TR4	40,0%	37,5%	
	TR5	-	-	
LTL2	TR1	-	12,5%	
	TR2	-	-	
	TR3	-	18,8%	0,379
	TR4	50%	62,5%	
	TR5	50%	6,3%	
Istm	TR3	-	50%	nc
	TR4	-	50%	

-at RTL1 localization, 50% of malignant and 40% of benign outcomes were associated with TI-RADS=4 (p=0.414);

-at RTL2 localization, 50% of malignant outcomes and 38.9% of benign outcomes were associated with TI-RADS=4 (p=0.470);

-at LTL1 localization, 40% of malignant and 37.5% of benign outcomes were associated with TI-RADS=4 (p=0.865);

-at LTL2 localization, 50% of malignant and 62.5% of benign outcomes were associated with TI-RADS=4 (p=0.379).

Depending on the localization of the nodule, correlating the anatomo-pathologic result with Asteria scores, the following aspects were noted :

-at LTD1 localization, all malignant findings and 62.5% of benign findings were associated with Asteria score=3 (p=0.032);

-for LTS1 localization, 66.7% of malignant outcomes and only 16.7% of benign outcomes were associated with Asteria score =4

Table 7. Correlation of Asteria score with anatomopathologic findings

Localization	Asteria	Anatomo-pathology		p
		Malignant	Benign	
LTD1	2	-	37,5%	**0,032**
	3	100%	62,5%	
LTD2	2	50,0%	100%	0,148
	3	50,0%	-	
LTS1	3	33,3%	83,3%	**0,009**
	4	66,7%	16,7%	
LTS2	2	-	80,0%	nc
	3	-	20,0%	
Istm	2	-	100%	nc

DISCUSSIONS

The guidelines indicate that the number of nodules has a low influence on their risk of malignancy, recommending the inclusion of this information in the report generated following conventional ultrasound in situations where individual nodules can be properly assessed and monitored. From the statistical analysis it was found that the majority of nodules were part of multinodular glands and only 6 of the patients had solitary nodules. Regarding the localization of nodular formations, this is not a predictive criterion for malignancy.

In this paper, the TI-RADS score criteria were analyzed. The score results themselves demonstrate that the solid structure of the nodule increases the susceptibility of the nodule to be malignant, just as thyroid overspill increases the susceptibility of malignancy.

Data from the literature state that the risk of malignancy of nodular formations showing intralesional microcalcifications is higher than that of nodules without such changes.

A multicenter retrospective validation multicenter study on 1058 nodules using final histology as the gold standard found a cancer rate in or close to the given range described in the EU-TIRADS guidelines and a satisfactory diagnostic value with 93% sensitivity and 97%. [28]

Based on literature data, a TR1 score has a risk of malignancy of 0.3%, a node with a TR2 score of 1.5%, a node with a TR3 score has a risk of 4.8%, a TR4 node has

a risk of malignancy of 9.1%, and a node with a TR5 score has a risk of malignancy of 35% [19] This study reflected that TR4 and TR5 scores are more often associated with malignant formations.

This study was performed based on the Asteria criteria, which present 4 classes of nodules. Using Asteria's criteria, the researchers calculated sensitivity and specificity to be 94.1% and 81%, respectively, in 86 nodules. [1] This study demonstrates the diagnostic potential of this investigation and reflects a higher percentage of malignant formations in nodules with high Asteria score.

Currently, the TI-RADS score does not analyze the functional status of thyroid nodules, thus scintigraphy presents an important investigation for the management of nodular formations.

Walfish and coworkers concluded that a total reliance on fine-needle biopsy without performing scintigraphy would lead to surgery for benign nodules suspected to be malignant and may increase surgical morbidity. [34]

Analyses performed with reference to the occurrence of thyroid carcinoma among "warm" nodules on scintigraphy have shown that this finding is an extremely rare phenomenon, thus, upon detection of a "warm" formation on scintigraphy, malignancy is excluded and the nodule does not require further investigation to exclude malignancy. [2]

According to the data analyzed in this paper elastographic examination combined with ultrasonographic examination contributes to proper management of thyroid nodular formations, contributing to decrease the number of invasive interventions that pose additional risks to patients.

CONCLUSIONS

Following the study correlation of the results of the performed investigations led to the conclusion that elastography has a significant role in the detection of malignant nodular formations, with an Asteria 4 score being associated with 66.7% of malignant formations in the LTL.The Ti-RADS score 4 was correlated with 50% of malignant formations in RTL. The correlation of imaging findings has a predictive role for

malignancy and are useful for the management of nodular formations, early diagnosis and increasing the quality of life of patients with thyroid nodule pathology.

Abbreviations

TIRADS- Thyroid Imaging Reporting and Data System

TRH- Thyroliberberin

TSH- Thyroid Stimulating Hormone

NIS- Na-Iodine symporter

TPO- Thyroid peroxidase

T4- Thyroxine

T3- Triiodothyronine

ATA- the American Thyroid Association

MIT- Monoiodotyrosine

DIT- Di-iodotyrosine

AACE- American Association of Clinical Endocrinologists

AME - Associazione Medici Endocrinologi

MEN- multiple endocrine neoplasia

FNA- Fine needle aspiration

ACR- American College of Radiology

TNM- Classification of Malignant Tumors

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THE IMPACT OF A HEALTHY LIFESTYLE AND DIET ON INSULIN RESISTANCE IN ADOLESCENTS – A CASE STUDY

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Abstract

To evaluate the effectiveness of lifestyle and dietary interventions in reversing insulin resistance and reducing the risk of type 2 diabetes in adolescents. A 16-year-old male with asthma and overweight status, calculated for a BMI of 27.7 kg/m², was markedly insulin-resistant (HOMA-IR: 8.2). A three-month intervention with a calorie-controlled diet providing 2,330 kcal/day and an appropriately sequenced aerobic and resistance training was instituted. The intervention normalized the metabolic parameters: insulin level 37.7 µIU/mL to 7.27 µIU/mL and HOMA-IR from 8.2 to 1.5. The results show that the loss of weight, change in diet, and exercise are very important in improving sensitivity to insulin, especially in overweight adolescents, even those with comorbid conditions such as asthma. Lifestyle intervention is very effective in reversing early metabolic disturbances among adolescents. Early detection, multidisciplinary management, and sustained behavioral change hold the key to prevention of long-term complications such as type 2 diabetes.

Keywords: adolescent, lifestyle, insulin, HOMA index, overweight status.

INTRODUCTION

The known risks of a sedentary life style are: gaining excessive weight, the development of cardiovascular diseases, increase in insulin resistance and diabetes.(2). Physical exercises have been studied to enhance insulin resistance (11) and play an anti-inflammatory role in the body (5). Some aerobic exercises, like walking and cycling are quite beneficial for obese people or those suffering from metabolic disorders. (9) Some evidence shows that the addition of resistance training to aerobic exercise has an even greater impact on the body. (10)

Insulin resistance (IR) is characterized by a suboptimal response of tissues to insulin action (4), preventing tissues from easily using glucose from the blood. This

mechanism leads to increased insulin production by the pancreas in an attempt to help cells and tissues use glucose and maintain normal blood glucose levels. (4)
Increased insulin resistance is associated with several diseases, including type 2 diabetes, cardiovascular diseases, and metabolic disorders. (14)

Paraclinically, insulin resistance is assessed by determining the HOMA index (The Homeostasis Model Assessment of IR - HOMA-IR).(6),(1) This is the ratio between the insulin secreted by the pancreas and blood glucose. The values are going to determine the degree of resistance: a value less than 2 is normal, a value above 2 indicates moderate risk of developing type 2 diabetes, and a ratio above 5 represents high risk in diabetic individuals. (3)

The incidence of type 2 diabetes in the pediatric population is increasing, with cases almost doubling in the United States. (7,13).

Case Presentation

A male adolescent, 16 years and 10 months old, with a known history of bronchial asthma, was presented to the "Sf. Ioan" Clinical Emergency Hospital for Children in Galați, with symptoms of respiratory viral infection-nasal congestion, productive cough, mild expiratory dyspnea-for three days.

Personal medical history: Bronchial asthma under treatment with Salbutamol inhaler, Fluticasone propionate inhaler, and Montelukast tablets.

Family medical history: Nonsignificant.

Clinical findings:

- Weight: 96 kg
- Height: 186 cm (BMI: 27.7 kg/m², classified as overweight)
- Examination results:
  - Congested oropharynx.
  - Nasal obstruction with productive cough.
  - Lungs: Vesicular breath sounds bilaterally with occasional wheezing. SpO_2: 98% on room air.
  - Abnormal cardiovascular, gastrointestinal, renal, or neurological systems

Lab data at the outset:

Basic work-up for the viral infection showed normal complete blood count and no evidence of inflammation. An allergy panel was also done which revealed positive results for Dermatophagoides pteronyssinus, Dermatophagoides farinae, and cat and

dog epithelia. However, since the patient is overweight, further metabolic tests were ordered:

- **Lipid profile:**
  - Total cholesterol: 146 mg/dL (normal <170 mg/dL).
  - HDL cholesterol: 41 mg/dL (normal ≥41 mg/dL).
  - LDL cholesterol: 82 mg/dL (normal 60–100 mg/dL).
- **Glucose metabolism:**
  - Blood glucose: 87.6 mg/dL (normal 70–110 mg/dL).
  - Insulin: 37.7 µIU/mL (normal 2.6–24.9 µIU/mL).
  - HOMA-IR: 8.2 (normal <2).

ȘThe increased insulin and HOMA-IR values placed the patient in the high-risk zone for diabetes type 2. Hence, medical advice regarding lifestyle interventions like diet and exercise were given and reassessment after three months was recommended.

Lifestyle intervention:

The patient was on a systematic diet, where the caloric intake was approximately 2,330 kcal/day, and he was forbidden from consuming fast foods, carbonated beverages, and processed sugars. The target weight was established between 68 and 81 kg, associated with physical exercises, including cardio and resistance exercises.

Follow-up:

After three months of following the recommendations, the patient returned for reevaluation. The results were as follows:

- **Blood glucose:** 81 mg/dL.
- **Insulin:** 7.27 µIU/mL.
- **HOMA-IR:** 1.5.

These results reflect the complete normalization of glucose metabolism and a significant reduction in the risk of type 2 diabetes.

Table 1: Changes in glucose metabolism parameters following lifestyle and dietary modifications.

Parameter	Glucose	Insulin	HOMA-IR
Initial values	87.6 mg/dL	37.7 µIU/mL	8.2
After 3 months	81 mg/dL	7.27 µIU/mL	1.5

DISCUSSION

This case underscores how the diagnosis of insulin resistance in adolescents is of utmost importance since it is a forerunner of T2DM and other metabolic disorders.

The clinical and laboratory findings of the patient presented in this case were indicative of a severe metabolic disorder with high insulin and a HOMA-IR index fourfold higher than the upper limit of normal. These results raise a high alert for immediate action, as insulin resistance if left unattended in adolescents will result in the progression of metabolic syndrome, cardiovascular disease, and overt diabetes.

1.1.Role of Lifestyle Interventions

The significant improvement in the metabolic parameters of the patient after three months of lifestyle modification shows that the body has the ability for metabolic recovery if appropriate interventions are given. The structured approach to weight management-a balanced, calorie-controlled diet and regular physical activity-directly targeted the major contributors to insulin resistance: excess adiposity and physical inactivity. It is consistently shown that even moderate weight loss, as low as 5–10% of body weight, can significantly improve insulin sensitivity by reducing visceral fat, decreasing inflammatory markers, and improving glucose uptake by skeletal muscles. (2, 5,9)

The patient's avoidance of fast food, sugary drinks, and processed foods aligns with evidence that diets high in refined carbohydrates and unhealthy fats exacerbate insulin resistance. On the other hand, nutrient-dense whole foods like vegetables, lean proteins, and complex carbohydrates can favorably influence glucose metabolism. (10) Regular physical activity, particularly the combination of aerobic and resistance training as utilized in this patient, enhances insulin sensitivity by both increased muscle glucose uptake and reduced hepatic glucose production. (4, 14)

1.2.Overweight and Asthma as Co-morbidities

The case also highlights the association between asthma, overweight, and insulin resistance. Asthma, a chronic inflammatory disease, shares common pathways with metabolic syndrome, including low-grade systemic inflammation, which may contribute to the development of insulin resistance (12). It has been demonstrated that bronchial asthma and obesity can synergistically interact by their effects on increasing pro-inflammatory cytokines, leading to increased insulin resistance and, consequently, the development of type 2 diabetes mellitus.(8) Furthermore, overweight adolescents

with asthma often reduce their physical activity due to dyspnea or fear of exacerbations, further compounding the risk of metabolic dysfunction. These interrelated factors could be addressed only by a holistic approach that would target the metabolic and respiratory aspects of the patient's health.

1.3.Normalisation of Parameters and Clinical Implications

The post-intervention results revealed normalization of insulin levels (37.7 μIU/mL to 7.27 μIU/mL) and HOMA-IR (8.2 to 1.5), indicating a drastic reduction in the patient's risk of developing T2DM. These improvements also remind one that early metabolic derangements in adolescents are reversible. This case points to the fact that insulin resistance is not only manageable but often reversible through non-pharmacological approaches if waylaid at an early stage. The Role of Healthcare Providers.

This case also identifies the invaluable contribution of general practitioners in spotting the susceptible adolescent and the prompt initiation of interventions. Periodic monitoring of glucose metabolism in overweight adolescents, especially when associated conditions such as asthma are also present, contributes to an early identification of insulin resistance. Besides, giving appropriate life-style advice and securing follow-through will lead to long-term success.

1.4.Long-term Outcomes

It will be important for this patient to continue these lifestyle changes beyond a three-month intervention to maintain metabolic health and prevent the recurrence of insulin resistance. Adolescence is a critical life stage where lifelong habits can be established, and improvements made during this period are likely to have a considerable impact on health outcomes in adulthood. Additionally, this case underscores the potential for scalable interventions that can be implemented at the community level to combat the rising prevalence of insulin resistance and T2DM in the pediatric population.

1.5.Broader Implications for Public Health

This case also shows the increasing demand for public health strategies to promote healthy eating and active lifestyles in children and adolescents. Since childhood obesity is on the rise worldwide, addressing lifestyle factors early in life is of paramount importance to avoid a cascade of metabolic diseases. Health care systems, schools, and families must collaborate to provide an environment that supports healthy behaviors and prevents the onset of metabolic disorders.

CONCLUSION

This case points to the impact that a healthy lifestyle and balanced diet could have in reversing insulin resistance and minimizing the risk of long-term complications in adolescents. At the start of the presentation, this patient's metabolic disturbance was profound-insulin high and with a high index of insulin resistance -both known to be predictive of the future development of type 2 diabetes mellitus. These findings signal the need for early identification and intervention, especially when the teenager has certain risks, including overweight conditions or other asthma comorbidities.

This adolescent was able to achieve remarkable improvements in metabolic health through structured and personalized interventions, including a calorie-controlled, nutrient-rich diet and regular physical activity, within an astoundingly short period of three months. This goes to show the capacity of the body to regain balance when given the right tools and changes in lifestyle.

This case further reiterates the role that healthcare professionals can play in early identification of warning signals for insulin resistance and informing patients and their families on the importance of preventive steps. The patient was able to improve not only immediate health markers but also dramatically reduce long-term risk associated with chronic metabolic diseases by addressing the case through the promotion of sustainable lifestyle changes rather than pharmacological interventions.

This case poignantly reminds one that healthy lifestyle, proper nutrition, and physical activity are cornerstones in the management and prevention of insulin resistance. The changes required are multidisciplinary-from health professionals, dieticians, and fitness experts-to ensure success over the long term. In adolescents, such

changes might be the pathway to healthy adulthood, avoiding a cascade of health complications and improving the quality of life.

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