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Kinetotherapy, Physical Education and Sports Performance: Educational Perspectives

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Kinetotherapy, Physical Education and Sports Performance: Educational Perspectives

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Bucharest, Romania

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STATE OF THE ART OF THE USE OF ARTIFICIAL INTELLIGENCE-DRIVEN RECOMMENDATION SYSTEMS IN THE FIELDS OF HEALTHY HABITS AND ACTIVE AGEING

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Abstract:

Background: Increasing life expectancy brings more age-related health issues. Enhancing physical, cognitive, mental, and social health is crucial. Promoting healthy habits com-bats stress and diseases. Recommendation systems, like collaborative filtering, tailor suggestions but face challenges. Techniques such as Artificial Intelligence and Machine Learning are vital. Personalized health recommendations improve lifestyles and mitigate issues; (2) Methods: A systematic review adhered to the general principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses was conducted; (3) Results: A total of 29 articles were included in this work. They address the topic of recommendation systems that use machine learning or artificial intelligence in the promotion of healthy habits; (4) Conclusions: This article reviews health-related activity recommendation techniques for the general population. With rising life expectancy and common health issues, effective recommendations are crucial for future public health. Limitations include excluding simpler models. Despite many proposals, systematic adherence mechanisms are lacking. Developing traceable, verifiable systems for healthy activity recommendations is vital for aging populations in developed countries.

Keywords: *gamification; healthy habits; recommender algorithm; health; well-being.*

Introduction

It is a well-known fact that human life expectancy is continually increasing. However, living longer also entails a higher risk of facing age-associated health issues, which can significantly diminish the quality of life. For this reason, it is essential for individuals to seek ways to improve and maintain their independence, skills, health, and well-being in all aspects: physical, cognitive, mental, and social (1). Moreover, given the fast-paced lifestyle that people lead today (2), both in young people and adults, it is crucial to promote healthy habits in all areas of life to mitigate stress and related diseases.

Historically, recommendation systems based on collaborative filtering (CF) (3), have been widely used due to their effectiveness in capturing user preferences. These systems can be easily implemented in various contexts without the need to extract

specific features of the recommended object, as is the case with content-based recommendation systems (4,5).

The recommendation algorithm is the main component of recommendation systems and can vary considerably in nature. There are several main variants, such as the previously mentioned CF systems (6), content-based systems (7), and hybrid systems (8). CF-based recommendation systems model user interests based on the similarity between users or items, using interaction data. On the other hand, content-based systems focus on the intrinsic features of the content to be recommended.

Although collaborative filtering-based recommendations are useful, they face challenges such as data fragmentation and the cold start problem (5). To overcome these obstacles, techniques such as data augmentation, data imputation, user profiling, content-based recommendations, and hybrid methods can be employed (9,10).

These recommendation techniques are often complemented by additional methods to incorporate contextual information into the recommendation process (11). This includes recommendations through contextual pre-filtering, contextual post-filtering, and contextual modeling (12).

With the advancement of the Internet and communication technologies, we are witnessing an exponential growth of available data. Extracting useful information from these large volumes of data is one of the most significant challenges. In this complex task, technologies grouped under the general terms of Machine Learning (ML) and Artificial Intelligence (AI) play a crucial role. Predictive models derived from these fields, extracted from the vast amount of data available across various platforms, can be used for multiple purposes. One of the most relevant, which has gained importance in recent years, is the development of recommendation systems.

Creating recommendation systems that provide relevant information to users is a significant challenge that has focused the efforts of researchers. Although many solutions have been proposed so far to implement recommendation systems, this is an ongoing path that requires further research and efforts (13).

For the development of recommendation systems, different ML algorithms are used, which, according to Mahesh (14), are classified into “Supervised learning”, “Unsupervised learning”, “Semi-supervised learning”, “Reinforcement learning”, “Multi-task learning”, “Ensemble learning”, “Neural networks” and “Instance based learning”, as shown in more detail in figure 1.

Personalized recommendation systems are particularly interesting as they tailor their recommendations to the specific conditions of each user. To develop these systems, it is essential to have data about the user. An initial assessment of the user's state is crucial. Additionally, other data are critical, such as historical user behavior data, including ratings, clicks, tags, and comments. These data allow for modeling user preferences based on their historical interactions, which enables the development of what is known as CF (15,16).

In the health sector, these tools are extremely useful. Many current health issues can be mitigated or even eliminated if people follow healthy recommendations in their daily lives. This would be the case for issues such as high blood pressure, high glucose levels, and physical inactivity, which are related to a modern lifestyle characterized by sedentarism, chronic stress, and high consumption of hypercaloric foods and recreational drugs (17).

Recommendation systems offer the possibility to motivate and engage users to change their behavior (18). They provide people with better choices and actionable insights based on observed behavior (19–21). To achieve this goal, creating a gamified

environment is interesting. Through the use of game-like components, people can be motivated and encouraged in non-gaming contexts to improve adherence to healthy practices (22).

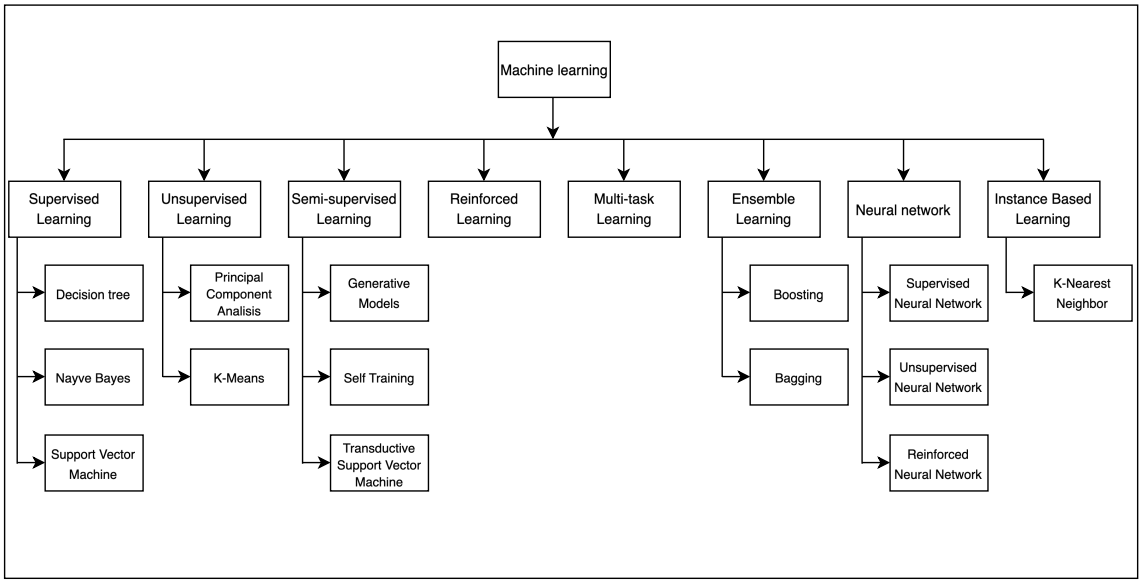

Figure 1. Mahesh classification of ML algorithms (14).

Due to this, and the interest of modern societies in maintaining and enhancing people's abilities for as long as possible, there is a need to conduct this systematic review with the aim of answering the research questions shown in Table 1.

Table 1. Research questions addressed by this systematic review.

Research question	**Statement**
RQ1	To what extent have personalized healthy activity recommendation systems been developed?
RQ2	What types of algorithms do they use? Do they use ML? Other AI techniques?
RQ3	Is gamification used to encourage healthy practices?
RQ4	What user data is used to make the recommendation?

To answer these questions, a review of the scientific literature was conducted with the goal of identifying published articles that discuss innovative research focused on the implementation of recommendation systems using recommendation algorithms, ML techniques, or AI to promote healthy habits and/or active ageing (AA). The ultimate aim of this study is to highlight the potential of recommendation systems in both explored and unexplored fields of the mentioned areas, to identify existing gaps, and to lay the groundwork for new lines of research in this domain.

Section 2 of this manuscript discusses the methodology and tools used to identify the relevant scientific literature to answer the research questions posed. Section 3 describes the results of applying this methodology, namely the identification of 29 relevant articles that meet the criteria established in Section 2. Section 3 presents the analysis of the selected articles. Finally, Section 5 offers the conclusions derived from this systematic review.

Material and methods

This review adhered to the general principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (23). In line with this approach,

a search strategy was defined, eligibility criteria were established, and a selection process was followed. As a result, a corpus of documents was obtained, which will allow for the extraction of results based on the proposed search.

Search strategy

The following normative databases were used to conduct the search process for the initiation phase of PRISMA on May 24, 2024: Web of Science (WoS), ProQuest, IEEE Xplore, Scopus, and Pubmed.

The aim of the search was to locate studies that addressed (1) the use of recommendation systems, (2) applied in the fields of physical activity (PA), exercise, AA, mental health, dietary habits, and sleep habits, and (3) the use of ML or AI.

In accordance with the search requirements, the standard query consisted of two blocks of terms, one for each of the aforementioned conditions, linked by logical AND operators. Within each block, the terms related to the search condition were connected using logical OR operators:

((“recommend* system*”) OR (“recommend* algorithm*”) OR (“recommend* platform*”) OR (“referral system”) or (“referral platform”) OR (“referral algorithm”)) (1)

AND

((health*) OR (“physical activity”) OR (“physical exercise”) OR (“active ageing”) OR (“active aging”) OR (ageing) OR (aging) OR (sport) OR (diet) OR (habit) OR (nutrition) OR (sleep) OR (“health* habit*”) OR (“mental health”)) (2)

AND

((“ML”) OR (“machine learning”) OR (“AI”) OR (“artificial intelligence”)) (3)

The results of the database searches, filtered by title and abstract, were uploaded to Zotero.

Selection criteria

Only articles written in English and relevant to answering the research questions were considered.

The following exclusion criteria were applied:

- Works not clearly focused on the fields of PA, exercise,AA, health, mental health, dietary habits, and sleep habits.
- Systematic review articles.
- Doctoral thesis.
- Articles focused on the technical characteristics of different types of recommendation algorithms without direct application to the proposed field.

Selection process

The files corresponding to searches in each database were imported using the JabRef software (24) to eliminate duplicates. Once duplicates were removed, the complete list was exported to a spreadsheet to manage the review of each one. The articles were divided into two blocks for the initial analysis. In this phase, each article was reviewed by two specialists, one from the technical field and another from the health field.

During the screening phase, based on the information contained in the title and abstract, the relevance of each article to answering the research questions was evaluated,

with each article being tagged on a scale from 0 (not relevant at all) to 3 (completely relevant), as was done in another review (25) . Articles with an average score of 2.5 or 3

points moved directly to the next phase. Articles with an average score of 0, 0.5, or 1 point were discarded. Similarly, articles rated with an average score of 1.5 or 2 points were reevaluated to decide whether they should move on to the full-text analysis phase or be discarded.

Next, the articles considered for the next phase, the full-text analysis, were reassigned to pairs of reviewers from the ICT and health fields, avoiding the reviewers assigned in the first phase. Again, in case of discrepancies in the scoring, another pair of reviewers would participate to resolve the decision.

Results

As previously mentioned, the aim of this study was to conduct a systematic review based on the PRISMA methodology to analyze and synthesize the findings from selected studies on the innovative use of recommendation systems employing various recommendation algorithms, ML, or AI techniques in the fields of PA, exercise, AA, health, mental health, dietary habits, and sleep habits. As illustrated in Figure 2, during the initial search, 2664 articles were identified from the selected databases.

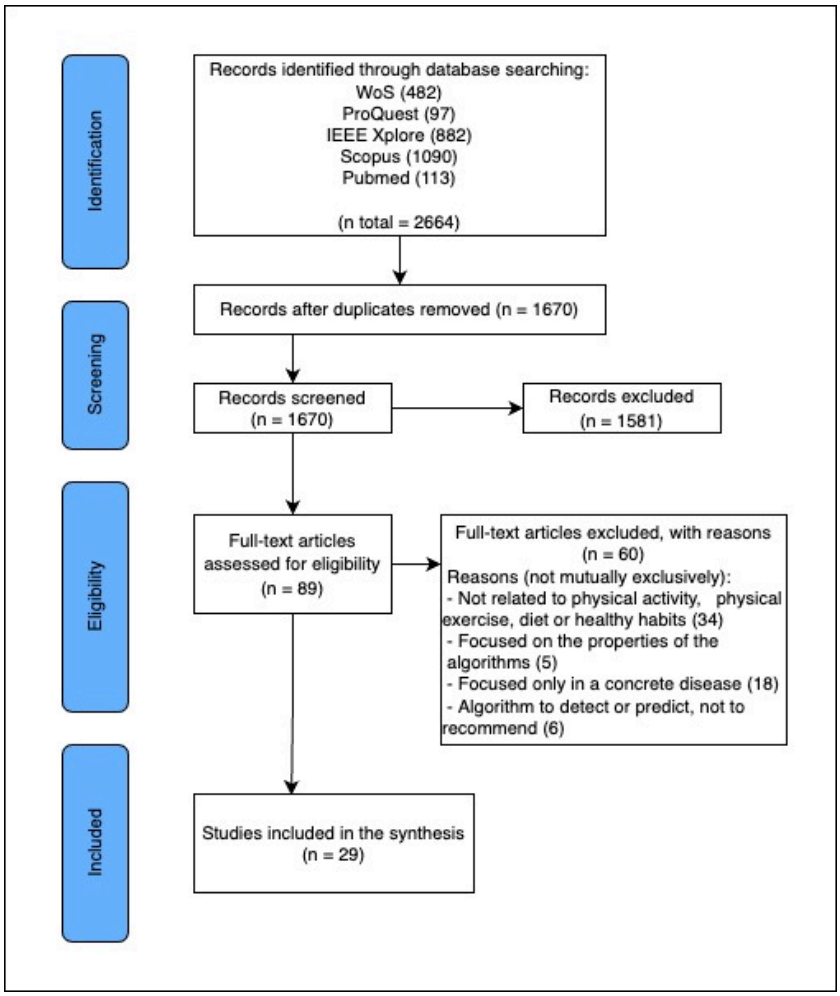

Figure 2. Flow diagram of the systematic review according to PRISMA guidelines.

Once duplicates were removed, 1670 articles were evaluated by their title and abstract, and assigned a score from 0 to 3 based on their relevance to the research. After

scoring, the majority of the articles (1581) received less than 1 point. Only one article received 1.5 points,
19 articles scored 2 points, 27 papers were rated with 2.5 points, and 42 received the highest score of 3 points. In total, 89 works advanced to the full-text reading phase.

These 89 selected works were thoroughly analyzed. In this analysis, each paper was reviewed by a different pair of reviewers. During this full reading phase, 60 works were excluded for various reasons, as shown in figure 1, mainly for not meeting all the inclusion/exclusion criteria. Thus, the final corpus for analysis in this systematic review was narrowed down to 29 works.

These 29 works (1,26–53), were deeply analyzed, focusing mainly on extracting the following information: (1) Domain; (2) Item recommended; (3) Recommendation Model; (4) Data from user; (5) Support database; (6) Technology Readiness Level; (7) Gamification (Reward), as shown in Table 1.

As can be seen in Table 2, the included works are grouped according to the domain under nine different domains. Under the “Diet” label, five works are grouped (37,45,46,49,50). In the “PA” category, another eight studies are included (26,31,32,40,42,44,51,53).

Under the label "PA, social activities and diet", one work is found (52). Two other works are grouped under “PA and diet” (47,48). Three works are classified under the label “PA and sleep quality” (1,29,34). The work by Anusari et al. (28) is classified under “PA, PE and diet”.

Two works (30,33) are grouped under the “PE” labe. Four more works are classified under “PE and diet” (27,36,38,39). Another work is classified under “PE and mental health” (43). Finally, two works under the “Sport” label (35,41).

Within the recommendation model, a wide variety of approaches are found, highlighting the well-known CF, content-based filtering, and knowledge-based filtering models. Within these models, various algorithms are developed, specified in Table 1 as “Technique used”.

Regarding the data collected from users for whom the recommendation is intended, the most notable are sociodemographic data, Body Mass Index (BMI), user preferences, and their levels of PA.

Concerning the database in which this data is stored, most of the works included in this systematic review do not mention the type of database used (conventional or distributed). However, from the information included in the articles, it can be deduced that many use conventional databases. It is important to note that three of them report the use of distributed databases. One work uses the "Microsoft Azure" database (26), and two others use blockchain technology to store their data (38,39).

Regarding the development level of the included proposals, they are found at TRL-3 (Experimental proof of concept), TRL-4 (Technology validated in the lab), and TRL-5 (Technology validated in a relevant environment (industrially relevant environment in the case of key enabling technologies)) (54).

Finally, in the last column of the aforementioned table, there is the item related to the use of gamification to engage the user and the element used for that purpose. Notably, only four works make use of this feature: Orte et al. (46) uses missions to encourage user participation; Lee et al. (40) tries to engage users through personalized feedback; Zhao et al. (53) encourages the participation through “Exergames”; and finally, Chatterjee, Prinz, et al. (32) use personalized messages and rewards to motivate users to perform the activities proposed in their system.

Table 2 summarizes the characteristics of the articles that progressed to the final phase. These characteristics can serve as a foundation for future research in the field of recommendation systems based on AI and ML in areas such asAA, Healthy Habits, Nutrition, PA, Physical Exercise, and Sports. As can be seen in Figure 2, the volume of research in the mentioned areas has been increasing over the years and appears to follow an upward trend.

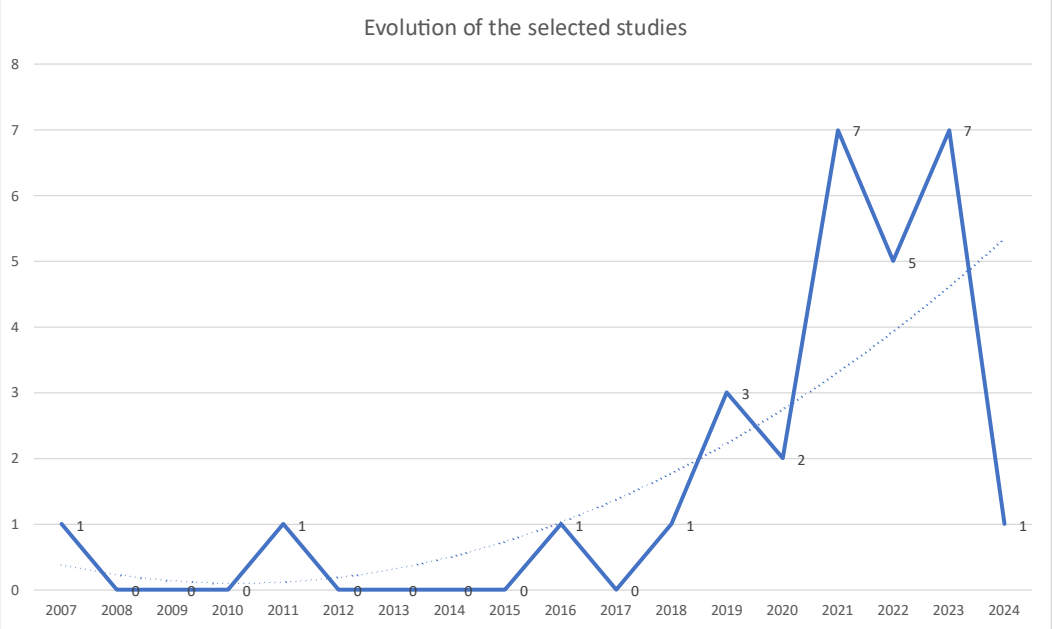

Figure 2. Evolution of the publication year of the included studies.

Discussion

In this section, we present an analysis of the data obtained from the 29 publications analyzed. We proposed four research questions (Table 1), which are discussed here:

RQ1: To what extent have personalized healthy activity recommendation systems been developed?

In this systematic review, we examined publications up to May 24, 2024, from major databases using the search query mentioned in Section 1. As illustrated in Figure 2, there is an upward trend in the number of publications in this field. This suggests that the relationship between recommendation systems utilizing AI or ML in areas such as PA, exercise,AA, mental health, eating habits, and sleep habits is still in its early stages of development, with a growing number of research studies on the topic.

Regarding the level of development and use of AI and ML, as shown in Table 2, it can be seen that it is in an early phase of development, as indicated by the Technology Readiness Level (TRL) (between 3 and 5) of the publications included in this work. Three works are at TRL-3 (Experimental proof of concept) (37,38,43), 18 are at TRL-4 (Technology validated in lab) (1,26–28,31–36,39–42,45,48,52,53),and eight are at TRL-5 (Technology validated in relevant environment) (29,30,44,46,47,49–51).

Furthermore, closely related to this low level of development, many of the works evaluated did not perform a validation in a real environment, with real users who could

assess the quality of the recommendations received. In most cases, the validation they claimed to have performed consisted of estimations on datasets. These calculations compared the performance of different recommendation techniques with expected outcomes.

Only in two studies (44,47) was validation with real users performed. In Mojarad et al. (44), they tested the functioning of their recommendations with a real user in four different scenarios with satisfactory results. In Palomares et al. (47), they conducted an online survey with 117 subjects who were asked three questions about their satisfaction with the recommendation made. According to this survey, 63.53% of the participants showed a preference for the more diverse recommendation made over a less advanced one.

RQ2: What types of algorithms do they use? Do they use ML? Other AI techniques?

In the analyzed works, a wide range of algorithms are used, as shown in Table 2. In terms of recommendation techniques, these vary from CF, content-based filtering, rule-based filtering, knowledge-based filtering, to various hybrid systems. The latter are present in 16 of the 29 works analyzed. It is important to note that in 13 works the implemented recommendation model is not mentioned.

Works employing “Supervised learning” use algorithms such as decision tree classifier (DTC), random forest classfier (RFC), support vector machine (SVM), support vector classifier (SVC), Naivë Bayes algorithm (NB), Gaussian Naivë Bayes algorithm (GNB), and support vector regression (SVR). At least one of these algorithms was used in eight works (27,28,31,37,38,48,51,53).

In four Works (34,37,48,53), algorithms classified as “Unsupervised learning” were used, specifically Aged LookBackApriori (ALBA), K-means clustering (K-MC), and genetic algorithm (GA). Another four works (1,31,38,45), employed “Instance based learning” algorithms, such as the K-nearest neighbour algorithm (K-NN). In one work, Hemaraju et al. (37) an algorithm classified as “Ensemble learning” eXtreme gradient boosting classifier (XGBC), was used. Finally, in three works, (33,43,51), “Neural networks” were used, specifically recurrent neural networks (RNN), convolutional neural networks(CNN), y long short-term memory (LSTM).

There is a significant heterogeneity in the use of different types of algorithms in each work. There is no clearly preferred option in the domain. Moreover, it is observable that the use of one type of algorithm does not exclude the use of others, even within the same proposal, as can be seen in works where up to three different types of ML algorithms are used (37).

Additionally, it is notable the presence of works that use recommendation techniques other than ML, such as AHPSort (50), PASP (44), or the “Fuzzy inference engine” (47).

RQ3: Is gamification used to encourage healthy practices?

In relation to the creation and use of a gamification environment, as shown in Table 2, its presence is quite limited. Only four of the 29 analyzed Works (32,40,46,53) employ this tool to promote and seek user adherence to the healthy practices recommended by the system.

Among the various gamification elements available, only missions are used to encourage user participation (46), personalized feedback (40), “Exergames” (53), and personalized messages and rewards to motivate users to perform the activities proposed in their system (32). The absence of simpler elements, such as leaderboards, is notable. Also noteworthy is the lack of any type of gamification environment in the two works that use blockchain technology as a support database (38,39), despite the fact that

blockchain technology facilitates such proposals due to its characteristics of automation, transparency, reliability, and security.

Considering the goal of any healthy activity recommendation system, like the 29 included in this systematic review, it should be essential to use all possible means to engage users and encourage their participation in the recommended healthy activities, in order to positively impact their health and well-being.

RQ4: What user data is used to make the recommendation?

Regarding the user data used for making recommendations, these are of a very diverse nature, as can be seen in Table 2. The data collected from users to make the recommendation include sociodemographic information, body mass index (BMI), user preferences, and their levels of PA. It is important to note that these data are used simply to determine to which group or cluster the users should be assigned to receive their recommendation. This cluster is determined, as appropriate, by BMI, sociodemographic data, levels of PA, or preferences, whether related to activities, PA, or diet.

Thus, the recommendation is not overly personalized for each user. By grouping users and making recommendations based on similarities, these suggestions turn out to be more generic and do not take into account all the particularities of each user, unlike what occurs in previous works by the authors (55). In the referenced work, various dimensions of the subjects' health are considered, such as physical function, mental health, vitality, diet, sleep, all assessed through validated and standardized questionnaires; injuries, illnesses, available material for training, and available facilities, as well as sociodemographic data. With all this information, it is possible to recommend challenges in a fully personalized and individualized way for each subject.

Of all the works present in this review, only one of them (46) uses a questionnaire to collect objective user data, in this case related to dietary habits.

Conclusions

This article provides a review of existing recommendation techniques for health-related activities aimed at the general population. Given the current trends of increasing life expectancy and common health issues in the developed world, these recommendations could play a crucial role in the coming years. Having effective recommendations with a high adherence rate may be essential for public health systems in the future.

Among the limitations of this study, it is noteworthy that solutions not using new data analysis paradigms such as AI and ML have not been explored. Therefore, solutions opting for simpler models or those that do not require massive computations may have been excluded from this analysis (55).

This study shows that although there are many proposals, they often lack a systematic process and mechanisms to encourage adherence to them.

According to the authors, it is reasonable to conclude that there are viable solutions available on the market. However, much remains to be done to develop traceable and verifiable systems that can be systematically offered to the general population for recommending healthy activities. This task may play a fundamental role in the current context of developed countries, where the population is ageing and suffers from diseases that could be prevented through healthy routines.

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Table 2. Synthesis of the studies. Ordered in chronological order and according to domain.

Author/Year	Domain	Item recommended	Recommendation Model	Data from user	Support database	TRL	Gamification (reward)
(Nouh et al., 2019) (45)	Diet.	Food.	CF and CBF. Technique used: K-NN.	Sociodemographic, health status, and personal information.	NEM	4	NEM
(Toledo et al., 2019) (50)		Daily meals.	NEM. Technique used: AHPSort.	Sociodemographic, heart rate, burned calories, and daily PA level.	NEM (conventional)	5	NEM
(Silva et al., 2022) (49)		Diet	CF. Techniques used: NEM.	Sociodemographic and eating habits.	NEM (conventional)	5	NEM
(Hemaraju et al., 2023) (37)		Foods depending on goals and preferences and hiking, running, bicycling...	NEM. Techniques used: K-MC, LR, DTC, RFC, and XGBC.	Sociodemographic and diseases.	NEM (conventional)	3	NEM
(Orte et al., 2023) (46)		Key food groups.	KBF. Technique used: RBR.	Modified food-frequency questionnaire.	Conventional	5	Yes (Missions)
(Lee et al., 2007) (40)	PA	Healthier diet and exercise.	NEM.	General index based on diet and medical records.	NEM (conventional)	4	Yes (Personalized feedback)
(Ali et al., 2016) (26)		Walking, running, climbing, bicycling, hiking…	NEM. Techniques used: RBR, CBR, and PBR.	BMI.	Distributed (Microsoft Azure)	4	NEM
(Li et al., 2018) (42)		Daily steps.	NEM. Technique used: Multi-level clustering.	Sociodemographic and PA level.	NEM (conventional)	4	NEM
(Mojarad et al., 2020) (44)		Healthy lifestyle (stretching, stop eating, listening to music…)	KBF. Technique used: PASP.	NEM	NEM (conventional)	5	NEM
(Zhao et al., 2020) (53)		Walking, running, climbing, bicycling, hiking…	CF. Techniques used: SVM and K-MC.	Sociodemographic, daily steps, active calories, walking/running distances, calendar events, location, player type, and exercise type.	NEM (conventional)	4	Yes (Exergames)

(Chatterjee, Pahari, et al., 2022) (31)		NEM	Hybrid (data driven and rule based). Techniques used: SVC,GNB, DTC, RFC, K-NN, and DC.	NEM	NEM	4	NEM
(Chatterjee, Prinz, et al., 2022) (32)		Daily and weekly steps	Hybrid (data driven and rule based) Techniques used: NEM.	Sociodemographic, activity levels, and health status.	NEM	4	Yes (Motivational messages and rewards)
(Vairavasundaram et al., 2022) (51)		Hour and daily steps.	NEM. Techniques used: RFC, SVR, RNN, and LSTM.	Sociodemographic, activity levels, and step count.	NEM (conventional)	5	NEM
(Wang et al., 2023) (52)	PA , social activities and diet	Meals and PE.	CF. Techniques used: NEM.	User preferences.	Conventional	4	NEM
(Palomares et al., 2022) (47)	PA and diet	Meals and PE (swimming, dancing, bicycling…)	NEM. Techniques used: GA and RBF using a fuzzy inference engine.	User preferences, physical condition, and goals.	NEM (conventional)	5	NEM
(Sadhasivam et al., 2023) (48)		Diet plans and workout routines.	NEM. Techniques used: K-MC and RFC.	Sociodemographic and BMI.	NEM (conventional)	4	NEM
(Erdeniz et al., 2019) (1)		Steps and sleep time.	CF and CBF. Technique used: K-NN.	Sociodemographic, physical condition, medical history, and chronic diseases, and cardiovascular diseases.	NEM	4	NEM
(Balpande et al., 2023) (29)	PA and sleep quality	Workout routines and food suggestions.	NEM.	Sociodemographic and BMI.	NEM (conventional)	5	NEM
(Dalla Vecchia et al., 2024) (34)		Sleep time and intensity of PA.	ALBA	PA levels and sleep quality.	NEM (conventional)	4	NEM

(Anusari et al., 2021) (28)	PA, PE and diet	NEM	Knowledge-based filtering. Used techniques: NB, RFC, DTC, and SVM.	Sociodemographic, user preferences, health conditions, PA levels, bedtime, and medical records,	NEM (conventional)	4	NEM
(Basnayake et al., 2021) (30)	PE	Play some sport, bicycling, running, walking and the intensity of the activity.	Expert system using Ontology.	Sociodemographic, exercise preferences, diet details, and medical records.	NEM (conventional)	5	NEM
(Chen et al., 2021) (33)		Running, hiking and indoor exercise.	A four-layer neural network.	Sociodemographic and rest heart rate.	Conventional	4	NEM
(Jamil, Qayyum, et al., 2021) (39)	PE and diet	Diet plans and workout routines.	NEM. Techniques used: NEM.	Sociodemographic and PA levels using IoT.	Distributed (blockchain)	4	NEM
(Jamil, Kahng et al., 2021) (38)		Diet plans and workout routines.	KBF. Techniques used: DTC, LR, SVM, and K-NN.	NEM	Distributed (blockchain)	3	NEM
(Annapoorna et al., 2023)		Walking, jogging, strength training, HIIT, and personalized menus.	NEM. Technique used: DTC.	Diet and exercise preferences.	NEM (conventional)	4	NEM
(Gaikwad et al., 2023) (36)		Diet plans and home exercise routines.	NEM.	Sociodemographic, nutritional deficiencies, and chronic diseases.	NEM (conventional)	4	NEM
(Mahyari & Pirolli, 2021) (43)	PE and mental health	Workout exercises and meditation.	Association rules and RNN.	NEM	NEM	3	NEM
(Donciu et al., 2011) (35)	Sport	Daily diet and workout.	NEM.	Personal information, hobbies, nutrition preferences, sports preferences, and declared purpose.	NEM (conventional)	4	NEM
(Li & Sun, 2021) (41)		Sports training items	CF. Techniques used: NEM.	NEM	NEM (conventional)	4	NEM

RBR: rule-based reasoning; PBR: preference-based reasoning; CBF: content-based filtering; RBF: rule-based filtering; CBR: case-based reasoning; AHPSort: Analytic Hierarchical Process for sorting; SVC: support vector classifier; GNB: Gaussian Naive Bayes; RNN: recurrent neural networks; PASP: probabilistic answer set; SVR: support vector regression; LSTM: long short-term memory; SVM: support vector machine; CNN: convolutional neural networks; ALBA: Aged LookBackApriori; NEM: not explicitly mentioned; NB: Naive Bayes algorithm; DC: Dummy Classifier; PA: physical activity; PE: physical exercise; GA: genetic algorithm.

THE IMPACT OF DIFFERENT TYPES OF PHYSICAL EXERCISES ON PROPRIOCEPTIVE SENSITIVITY AT THE LEVEL OF THE LEG-ANKLE COMPLEX WITH AN EFFECT ON INCREASING STABILITY AND SPORTS PERFORMANCE

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Abstract

The disruption of proprioceptive feedback *(due to trauma or injury)* can contribute substantially to excessive or inadequate loading of a joint and is one of the factors with a significant contribution to progressive joint degeneration, but also to ongoing deficits in dynamics, balance and coordination the joints. In order to prevent or reduce the severity of traumas at the level of the ankle and foot complex, it is necessary to prescribe a specific proprioception training, with a prophylactic role but also to allow injured athletes to return to the pre-trauma performance level, after ligament injuries or muscular. As the result of the publication of several clinical studies, we know that individuals diagnosed with neuromuscular response deficiencies are less able to maintain stability and postural balance. Consulting the specialized literature, we found that there is a lack of scientific evidence regarding the impact of the form and way of lower extremity proprioception exercise. Considering the importance of proprioception in postural stability, movement control and injury prevention, we believe it would be beneficial to understand the effects of different types of exercise on proprioceptive sensitivity. In order to cover the research gap, we designed a cross-sectional study to examine the effects of physical exercise on ankle proprioception in young athletes.

Keywords*:* proprioception, sensory, postural stability, sport performance

Introduction

Effective movement in a bipedal position in a three-dimensional space under the notable influence of gravitational force is largely possible due to proprioceptive sensitivity, sensory feedback that contributes to maintaining global posture *(postural balance)* and segmental posture (joint stability), but also to the conscious sensation of movement, acceleration *(muscle sense)*. This function is dependent on the integration from the nervous system of primate information from specialized receptors *(proprioceptors)* located in the skin, muscles, tendons, ligaments and joint capsules *(Lephart, Pincivero and Giraldo 2001)*.

A number of scientific studies, published relatively recently, indicate a significant correlation between proprioceptive sensitivity and postural control of the lower limb *(Clark, Loyd and Webster 1999; Colledge 2001)*.

Moreover, disruption of proprioceptive feedback due to some trauma or injury, such as ankle injury, *(Perrin 1998)* can contribute to excessive or inadequate loading of a joint *(Skinner and Cannon, 1998)* and is one of the factors with a significant contribution to progressive degeneration of joints, but also of continuous deficits in dynamics, balance and coordination of joints *(Riemann, 2003)*. Many clinical studies have demonstrated that individuals diagnosed with neuromuscular response deficiencies as a result of joint trauma and degeneration are less able to maintain postural stability and balance *(Cornwall and Murrell, 1992; Forkin, Koczur and Newton, 1998; Garn & Newton, 1999; Pintsaar, Brynhildsen, 2001)*.

Given the importance of proprioception in postural stability, motion control and injury prevention would, we believe, be beneficial to understand the effects of different types of exercise on proporioceptive sensitivity.

The ankle and foot complex is a critical structure in postural stability, and the injury rate is very high in all sports disciplines. In order to prevent or reduce the severity of trauma at the level of

the above-mentioned complex, it is necessary to prescribe a specific proprioception training, both with a prophylactic role, but also to allow injured athletes to return to the pre-trauma performance level, after ligament or muscle injuries.

The scientific community is still discussing the effectiveness of different types of exercise on proprioceptive sensitivity *(Ashton, 2014).* Some studies conclude that proprioception can be improved through exercise, especially specialized exercises that require three actions: joint proprioception, balance ability, and neuromuscular control *(Irrgang 2010; Rosenbaum, 2013).*

Following a synthesis of the specialized literature, we found that scientific evidence is missing regarding the impact of the form and manner of exercise on lower extremity proprioception. To bridge the research gap, we designed a cross-sectional study to examine the effects of physical exercise on ankle proprioception in young people by comparing the sense of passive movement, kinesthesia, between four groups, handball players *(with a minimum 5-year practice),* artistic gymnastics / sports dance *(also with a practice of more than 5 years)* people who practice jogging *(at least three times a week)* and sedentary population.

Such an approach would contribute to a better understanding of the effects of long-term physical exercise on proprioceptive function and could subsequently contribute to the development of specific programs aimed at improving proprioceptive function in different age groups or proprioceptive deficiency patients.

Subjects & Methods

A number of 24 subjects, *(12 female and 12 male)* between the ages of 19 and 24 were selected to participate in the study, Each group consisted of 6 subjects *(three female and three male)*, and the distribution of subjects in the corresponding groups was carried out according to the type of activity practiced.

Thus the first group included long-term jogging/running enthusiasts (A). The second group, handball players *(with a minimum practice of 5 years)* we coded this group (H). The third group consisted of practitioners of rhythmic gymnastics or sports dance, group (G) and finally the last group, sedentary persons *(who do not regularly practice any kind of physical activity)* formerly formed by students of the Romanian-American University from Bucharest *(three students respectively three students)*, coded group (S).

It should be noted that all 24 study participants were clinically healthy, had no symptoms of cardiovascular or pulmonary conditions, and no history of significant musculoskeletal injuries or trauma, and all voluntarily expressed their consent and desire to participate in this project.

Colecting Data

The tests took place between May 24 – May 28, 2024 in one of the laboratories on the ground floor of the Romanian-American University in Bucharest and at the COR Complex in Izvorani county, Ilfov county. Both locations are isolated enough not to distract subjects with ambient noises, but have benefited from adequate light and ventilation. Following anthropometric measurements *(height and weight)*, the subjects participated individually in a data collection session.

The device used for this purpose is basically a mobile platform that rotates around a single axis in two directions. With the foot resting on this platform, complex movements, planting dorsiflexion or inversion-eversion of the foot and ankle may occur. That platform is moved by an electric motor that rotates the foot on an axis at a rate of 0.4° /sec. Movement can be stopped at any time using a hand switch. The device is also equipped with a suspended scale and a fixed pulley supported by a leg, which is outside the device. A cuff attached to the lower end of the scale is wrapped around the lower thigh of the subjects. Through adjustments to the length of the cuff, the extremity is lifted by the scale and its weight is recorded when a subject completely relaxes his thigh. After this, the cuff is attached to one end of the rope around the pulley and the other end is hung with weights. The extremity can be adjusted where the foot is in contact with the platform. By

adding or reducing weights, the investigator can standardize and control the amount of lower extremity weight that is on the platform during testing.

For data collection, each subject was placed on an adjustable seat, and its dominant foot was placed so on the platform that the axis of the apparatus coincided with the plantar dorsiflexion axis or the inversion-eversion axis of the foot and ankle joint. The hip, knee and ankle were positioned at 90°. Fifty percent of the weight of each subject's lower extremity was supported on the platform by using the thigh cuff suspension system to control unwanted sensory cues from contact between the instrument and the plantar surface of the foot.

During testing, subjects' eyes were closed to eliminate the variable related to visual stimuli. The data collected in each test move started with the foot placed in a starting position of 0°. Subjects were instructed to focus on the foot and press the switch manually when they could sense movement and identify the direction of movement.

After performing two practical samples, a formal data collection was carried out. The motor was coupled to rotate the foot in dorsiflexion or plantarflexion, or inversion or eversion at a random time interval between 2 and 10 seconds. The rotation angles of the platform and the direction of the movements were recorded as the direction of passive movement. At least 12 randomized rounds were performed (three for movement in each direction). The kinesthesia of plantar flexion and dorsiflexion was first measured. Measurement of inversion and eversion kinesthesia followed.

Data analysis

All variables are presented as arithmetic mean of deviation (AD) and standard deviation (AS). The independent test (TI) was used to test whether there were significant differences within the group. The associated T-test was used to determine if there was any significant difference between the data collected from the dominant and nondominant parts within the group. If there was no significant difference, the data on both sides and both sexes were pooled.

In each group, values for the sense of passive movement of the foot and ankle complex in associated movements, dorsal versus plantar flexion, inversion versus eversion, were compared using the associated T-test. One-way analysis of variance was used to estimate significant differences in the values of each sense of passive movement of the leg and ankle complex between groups. Tests were performed when necessary to isolate differences, and $P \leq 0.05$ was considered statistically significant.

Results

Although there were significant differences in body weight and height between study participants, no notable differences in body mass index (BM) were found among subjects. I mention the fact that there were significant differences in proprioception in the ankle joint between the three groups in the inversion and eversion measurements. Group (G) was able to perceive the inversion movement of 2.79 ± 0.64° and 3.17 ± 1.12° of eversion movement. The values of passive reversal motion and eversion motion were 4.33 ± 2.04 ° and 4.76 ± 2.59 in group (H), which was 31% to 35% higher than in the case of group (G). The sedentary group (S) perceived passive movement values in inversion and eversion higher by 50% to 55% than the gymnastics group values. No significant difference was found between group (A) and sedentary control group (S). Table No. 2 shows the results of the statistical analysis of the kinesthesia values measured in motion in different direction in the four groups.

Table nr. 1 Kinesthesia in dorsal flexion / plantar flexion and inversion / eversion

Movement pattern	Kinesthesia (degrees)	Grup (A) (degrees)	Grup (G) (degrees)	Grup (H) (degrees)	Grup (S) (degrees)
Dorsal Flexion	Average / AS	*2,53 ± 0,96*	*1,93 ± 0.65*	*2,53 ± 0,88*	*2,47 ± 0.83*
	Minim	*1,35*	*1.07*	*1,30*	*1,40*
	Maxim	*4,40*	*3.35*	*4.64*	*4,30*
Plantar Flexion	Average / AS	*2,55 ± 0,80*	*1,92 ± 0,62*	*2,61 ± 1,12*	*2,51 ± 0,86*
	Minim	*1.60*	*1,07*	*1.35*	*1.58*
	Maxim	*4,70*	*3.14*	*5.64*	*4,60*
Inversion	Average / AS	*5,30 ± 2,60*	*2,79 ± 0,64*	*4,33 ± 2,04*	*5,41 ± 2,71*
	Minim	*2.50*	*1,30*	*1,03*	*2.59*
	Maxim	*12,78*	*4,90*	*7,98*	*13.23*
Eversion	Average / AS	*5,16 ± 1,80*	*3,17 ± 1,12*	*4,76 ± 2,04*	*5,18 ± 1,78*
	Minim	*1,91*	*1,95*	*1,22*	*2,01*
	Maxim	*7.65*	*6,31*	*10,15*	*8.31*

Our study confirms that rhythmic gymnastics/sport dance have a long-term beneficial influence in terms of proprioceptive function in the ankle joint, significantly better than the sedentary population or practitioners of a sports game, handball in this case. Surprisingly, group (A) subjects did not perform significantly better in ankle joint kinesthesia compared to their sedentary counterparts. According to the description by Irrgang and Neri *(2009),* propriocpeitive exercises require consideration of three parts: joint proprioception, balance ability, and neuromuscular control. Successful improvement of proprioception is conditioned by the choice of the correct forms of exercise to progressively stimulate the necessary requirements during the activities in which the individual participates.

A cross-sectional study of knee and ankle joint kinesthesia among three groups of people (age III) showed that long-term Tai Chi exercises can significantly improve knee and ankle joint proprioception compared to runners/swimmers. In addition, long-term runners/swimmers could not achieve better performance in perceiving passive dorsiflexion movement and plantar flexion of the ankle joint *(Xu, et al, 2004)* than did a sedentary group. Movements in Tai Chi are extremely accurate because the specificity of joint angles and body position is of critical importance in properly performing each shape (Jacobson, Chen, Cashel and Guerrero, 1997). Awareness of the position and movement of the body is required by the nature of the activity, such a form of exercise contains all the necessary components in the formation of proprioception and benefits from proprioception.

Schmitt and colleagues *(2005)* studied the effects of ballet training for 5 months on the sense of ankle position. 42 dancers with more than 10 years of dance experience and 40 controls with similar ages but no specific sports training participated in the study. Passive angle replication tests (sense of joint position tests) were performed during the pre-post-workout program.

The instruction consisted of 15 to 16 hours per week of classical ballet and 4.5 hours per week of modern dance. No significant differences were found in the sense of articular position in either the pre - or post-test of the training program. It is well known that ballet and other dances have a proprioception component, balance ability, and neuromuscular control. Ballet can thus be considered a proprioceptive exercise. The possible cause of ballet's undetectable effect on proprioception in Schimitt's study may be related to the sensitivity and reliability of the test method.

Beynnon et al. *(2000)* compared the accuracy, repeatability, and precision of seven techniques of joint position sense and one technique for measuring joint kinesthesia in subjects without a history of knee injury. Joint kinesthesia concluded that study, was more accurate than each of the joint position sense techniques. They therefore recommended that studies designed to

assess proprioception should consider the use of kinesthesia, which should lead to increased strength and sensitivity to detect significant differences, if they really exist. In Schmitt's study, proprioception was examined by measuring the sense of joint position under weightless conditions. The test method may not have been sensitive enough to detect proprioception function.

Another factor that influences the impact of exercise on proprioception is the duration of training. Xu, et al. *(2003)* examined the effects of a 15-week Tai Chi exercise program with three sessions per week consisting of 1 hour for each session. The results demonstrated that the significant training effect of kinesthesia was found in the knee joint, but not in the leg and ankle complex.

The study presented in this article shows that rhythmic gymnastics/sports dance presents a superior long-term effectiveness in terms of the development of proprioception at the level of the ankle/foot complex, compared to the practitioners of a sports game *(handball)*. Rhythmic gymnastics is, by its specificity, a non-cyclic sport, but which requires an increased level of coordination, rhythm, agility and resistance.

Probably very relevant to the present discussion, in terms of postural control capacity contains all the components of proprioceptive exercise. Specific movements *(movements, turns, jumps and landings)* particularly stress the complex represented by the ankle/foot. In addition, the very narrow support base of the body has a very high demand for balance control capacity. Therefore, awareness of joint position and movement is always emphasized during gymnastic or dance executions.

Comparatively, long-term running is a cyclical exercise that does not require awareness of joint position and movement. In addition, most runners practice this form of exercise only to improve their aerobic capacity and for recreation, they do not pay much attention to the techniques involved in the exercise. This could be, we believe, one of the reasons why long-term running did not show notable benefits for ankle and foot kinesthesia in this study.

The results recorded by us and presented in this article seem to confirm the findings of another study *(Xu et al. 2004)* denoting that cross-country running *(over a period of 6 months)* did not contribute to significantly better kinesthesia than in sedentary people. It is notable that the present study, which focused on the 19-22 age group, reached the same conclusions regarding the effects that running has on proprioception as in the case of the 2004 research, but which addressed people of middle age.

Since there are no references in the literature to the measurement of kinesthesia in inversion and eversion, the present study presents for the first time the meaning of passive movement in inversion and eversion in young people who practice different sports disciplines. The group consisting of gymnastics/sports dance showed significantly superior control of these movements compared to the groups of runners, sports play (handball) and the sedentary population.

Conclusions

The causes that contributed to these differences are multiple, for the solution of these aspects a separate discussion, perhaps even further studies, is probably necessary. The results noted by us and brought up in this article could correlate with the characteristics of the movements specific to gymnastics that seem to particularly demand the proprioceptors of the leg-ankle complex. The range of supination of the bare foot, or with minimal protection, in rhythmic gymnastics seems to require in particular the stabilizing muscles whose fine contraction precisely regulates the tension and length of the plantar vault. This muscle activity would result in entrainment of effects on the neuro-muscular spindles and Golgi organs, as well as other proprioceptors.

Practicing long-term rhythmic gymnastics results in increased proprioceptive sensitivity in the ankle and foot joint. Passive movement was significantly more effective in medial-lateral

direction. Long-term running could not demonstrate the same training effects on ankle and foot complex kinesthesia in runners. However, long-term running can improve the sense of passive movement in the medial-lateral direction, but has not reached a statistical level. The results suggest that proprioception could be improved by exercise. However, the form of the exercise and the duration of the training are essential to achieve notable effects.

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OPTIMIZING OF THE TECHNICAL-TACTICAL PLAY CAPACITY BY SPECIFIC PHYSICAL TRAINING PROGRAMS WITH AND WITHOUTTHE BALL IN U18 FOOTBALLERS

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Summary

The specific physical training with and without the ball in football aims at developing the motion qualities and the effort capacity of the body, adapted to the technical and tactical tasks of the football game.

This is made by approaching prevailingly the aspects of thorough specialization; this is why the use of the exercises of a selective, analytical type is predominant, in which the effort load is dosed depending on the motion quality aimed at. The specific physical training is characterized by movements developing and improving the physical qualities requested by the particularities of the football game technique and tactics. Assuring a superior physical training, a request of our game conception, is made only if at its basis stands the multilateral physical training and the harmonious combining of the general physical training to the specific one.

Key words: experimenting, instruction, footballers, physical capacity, program, objectives, planning, tests, specific;

Introduction:

The means selected are among the basic and specific technical methods, combining the objectives of the technical advancement to those of the manifestation to maximum level of the motion qualities required in any of the executions performed.(Hagar, A.; Melo, L.; Hills, G.; Kenshur, N.; Dickinson, S. A new aerobic fitness score based on lactate sensing during submaximal exercise. Appl. Physiol. Nutr. Metab. **2020**, 45, 784–792.). It does not replace the effects and the effectiveness of the general physical training, nor does it exclude it.

In football, performance is strictly determined by the level of development of a complex set of motion qualities, (Giovanni Trapattoni, Emilio Cecchini, 2005, page. 190). Specific physical training is made by strictly specialized means which develop the combinations of qualities, primarily determined by the particularities of football, by the muscle groups employed to effort, by the strain, etc. The football players' yield is determined by the relation between the two types of physical training. In order to carry out the physical training to a superior level, supplementary factors are used, such as the recovery methods of vitaminization, nutrition, practices at an average or high altitude and adequate equipment (simulators, etc). (Bompa Tudor, Buzzichelli Carlo A, 2021 / 4th Edition in Periodization – Theory and methodology of sports training, Publishing House, *Lifestyle Publishing*., page 231). For the professional football players, there may be planned both separate lessons of general physical training, and specific physical training.

Premises of the research

Upon the process of specialty documenting to a national level and by comparative reference to the international level on the practices' patterns and the manner of approach of the actual practices, it results that, nationally, we are outrun by the great football academies and schools in Europe, this phenomenon being tested by use of practical performances.

The fact that we have the exact information specific to the use and administering in the practice of four levels youth footballers, of the programs of specific physical training with and without the ball during all the training periods programmed and dosed correspondingly to the respective period of time by the great football Academies in Europe, motivate us even more to test in practice at a national level, the application of the specific physical training programs with and

without the ball, so that, in the end of the practical experiment, we bring real, tested arguments that it is worth implementing the use of the specific physical training programs with and without the ball, including in U18 category of youth players (17 – 18 years old) / U18.

The purpose:

Consists of demonstrating the effectiveness of the approach of a new type of training in terms of the administering, during practice in all the training periods, the specific physical training programs with and without the ball to the level of U18 youth footballers, dosed and programmed appropriately to the preparing period, aiming, by this process, at the optimization of the specific physical training that will eventually lead to the increase of the technical tactical game capacity.

At the basis of the demonstration of this process lies the previous experiment, following which the tests and trials have been filtered, emphasizing the quality of the specific physical training programs with and without the ball, which is beneficial to U18 youth footballers' instruction process, lied at the basis of the carry out of the experimental process undergone during two seasons, in the Junior Footballers National championship, approximately 2 years, carried out within the experiment that we chose, more exactly, within the **Academy F.C. Argeş**. I make the mention that, by obtaining the consent in writing of U18 player groups aged 17 -18 years old, within the **Academy F.C. Argeş.** I have had the opportunity of carrying out the practical experimental process under real, official conditions for obtaining sports performances, with quality material and human values nationally, but also at a European level by the finite products that they have in their records.

The tasks of generating research objectives: - The correct and current identification of the patterns of specific physical training used by the great football academies in Europe:

- The identification of the modern sources which help creating and performing specific physical training programs with and without the ball;
- The correct informing of the collaborators within the practical experiment on the manner of creating, programming and putting into practice the training programs;
- Identification of the trials and tests, general and specific, which would emphasize the valorisation of the effects issued by the administering of programs into practice;
- Demonstration of the effectiveness of putting into practice of the programs by means of research methods, the experiment method, the statistical- mathematical method through the gathering and processing of statistical data, but also their comparative interpretations
- Confirmation of hypotheses and demonstrating by means of the practical experimental process.

The hypotheses of the research process:

We envisage that by rethinking the manner or use of the program and planning to the level of B youth players within the national football, by implementing the specific physical training programs with and without the ball will have a favourable impact on the optimization of the technical tactical play capacity at this age, increasing the general performance level and the promotion of youth players even from 17 -18 years old.

- We envisage that, if we elaborate and administer into the instruction process specific physical training programs with and without the bal to the level of U18 youth footballers, rethought over the way of conceiving and their content achieved by modern quality processes with the help of the Soccer Tutor Tactics Manager 3D Software, especially conceived for the football coaches, but especially, key moments of their introducing to the planning at this age, dosed correspondingly in the training periods, will contribute effectively and efficiently to the improvement of the technical tactical play capacity and implicitly to the increase of performances;
- We think it is useful to implement the specific physical training programs with and without the ball in the instruction process in all the training periods, conceived and dosed depending on the period, this aspect being helped by the way of modern conceiving, having at its fundament the Soccer Tutor Tactics Manager 3D Software, which is a real source of inspiration for the

academies and children and youth players facilities, legally approved by the International Commissions of children and youth players in football upon the Tehnical Commission UEFA agreement.

Research Methods used within the experimental process:

The national and international specialty literature study method: The observation method; The modern method of conception and presentation of the training themes by use of the Soccer software; Tutor – Tactics Manager; Tests and measurements' method; Statistical- mathematical method; Experimental method; Graphical and tabular method.

A) Tests for assessing the general physical training level: *Sprint running of 30 m and 100 m (V_{30} and V_{100}) – for the running speed; Resistance running on 30 m and 100 m (V_{30} and V_{100})- for the running speed; Resistance running on 1600m and the Cooper Test (ALR1600m and TC)*; *Push- ups (FL)*; *Pull-ups (TR)*; *Trunk lifts lying on the back (ABD)*; *Trunk extensions (SP)*; *Genuflections (G)*; *Long jump (SLG)*; *Vertical jump (SV)*; *Trunk bending by arms elongated (ITR)*

B). Tests for assessing the level of specific physical training of the football players: Holding the ball in the air from the ground with the foot and with the head (MML); Holding the ball in the air from motion with the foot and with the head (MMD); Kick from 30 m (Ş$_{30}$); Commutation (N); Striking the ball with the head (LMC); *Complex test no. 1 (PC1); Complex test no. 2 (PC2)*

C). Specific tests for the goalkeeper : *Drop kick with the foot on a target point (DMPF)*; *Drop with the hand on a target point (AMPF)*.

Personal contributions to accomplishing the planning of the programs experimented into practice

Model of operational program for specific physical ball training

CODE	Nr. Ex.	Means		Repetitions		Series		Intensity	Volume
			Distance	r.	Pause	Nr.	Pause		
1	2	3	4	5	6	7	8	9	10
Technical methods (CPT Code)									
Ball Handling— pass — getting back — goal shooting									
CPT	1	-	15 m	10	80" 1	3	6'	4/4	450 m
CPT	2	-	10 m	10	60"	4	8:	4/4	400 m
CPT	3	-	10 m	10	60"	4	6'	4/4	400m
CPT	4	-	15 m	10	80"	3	6'	4/4	450 m
CPT	5	-	20 m	10	90"		10'	3/4	600 m
CPT	6	-	20 m	10	90"	3	10'	3/4	600 m
Trapping – cone driving – goal shooting									
CPT	7	-	30 m	10	120"	2	10'	3/4	600 m
CPT	8	-	35 m	10	140"	2	10'	3/4	700 m
CPT	9	-	20 m	10	90"	3	10'	4/4	600 m
CPT	10	-	30 m	10	120"	2	10'	3/4	600 m
Passing the ball to a half-active opponent – goal shooting									
CPT	11	-	20 m	10	90"	3	10'	4/4	600 m
CPT	12	-	20 m	10	90"	3	10'	4/4	600 m
CPT	13	-	20 m	10	90"	3	10'	4/4	600 m
CPT	14	-	15 m	10	80"	3	5'	4/4	450 m
Technical and Tactical Methods (CPTT Code)									
Trapping — leading — one — two - pass									
CPTT	1		40 m	10	150"	3	10'	3/4	1200 m
Pass - trapping - opening — leading - centering - completion									
CPTT	2	-	30 m	10	120"	3	10'	3/4	900 m
CPTT	3	-	30 m	10	120"	3	10'	3/4	900 m
CPTT	4	-	30 m	10	120"	3	15'	4/4	900 m
Passes in three — leading - opening — centering - completion									
CPTT	5		50 m	10	170"	3	15'	4/4	900 m
Passes in two- leading -centering - completion									
CPTT	6	-	30 m	10	120"	3	10'	4/4	900 m
Pass - leading - one - two - completion									
CPTT	7	-	20 m	10	90"	4	10'	4/4	800 m
Pass — place change leading- launching— completion									
CPTT	8		50 m [10		170"	2	15'	3/4	1000 m
Ball throwing from the margin - trapping —opening— leading - centering – completion									
CPTT	9	-	30 m	10	120"	3	10'	4/4	900 m

Model of microcycle applied weekly to U18 junior team of Academy F.C. Argeş in the National Junior Championship (competition period 2023/2024)The pre-competition period – Defence Area

O.1. – Improving the general and specific capacity to move in the field in a direct or indirect relation to the ball, opponent and teammate.

O.2. –Improving the capacity to lead the ball under specific game conditions with the semi active and active opponents.

O.3. – Developing the sense of support from the own teammates having an intensity specific to the official match.

Day	Time	Intensity	Content, means
Sunday	90'	Medium	Active players' recovery through training, bath, pool, massage, sauna, rest, sleep full recovery;
morning	90'	High	Training with the reserve players
	60'		Medical examination (health state)
	30'		Analysis of the game on Saturday and the next opponent
Monday morning	100-120'	Medium	- Aerobic physical training (functional training) - Specific physical training program with and without ball (PFS) - Warm-up - 1800 m; - unspecific means: 3x1600 m (cu 5' pause and pulse 132-156) or 3' 800+3' 400+3' 200 m. - specific means (using the ball without goal shooting) roundtrip running in twos with and without an opponent; in two by supporting the player in an advanced position; in three with their interference în (one goes down, the other gets in front of ball holder breaking free from his opponent). - strength training: 5-6-7 circuit worshops; 60-80 one-leg jumps; medicine ball exercises (4 sets of 15 throws), 30 m launches (absence of contraction).
	45'-60'		• Recovery
Day	**Time**	**Intensity**	**Content, means**
Monday afternoon	90'	Medium	- Technical and tactical training (couples, triangle, square) - Complex exercises for 3-4 completion positions (groups on the edges, on center and changing areas); - using head for game development and movements in the area, for defenders; School game.
	60'		Recovery
Tuesday afternoon	90--120'	High	Complex Training - Conception Homogeneity - Study on the future opponent's features — in junior game - Anaerobic effort by individual tempo training
			- Individual possibilities; - Practice of game in attack by functional groups in all areas; - PFS Program using the ball; - Playing on 2/4 of land, 6 X 6 with strict marking, breaking free from the opponent (3Rx3 'with int. T), aiming at: - the use of free areas and lanes (interference, crossing, surrounding, shield); - when the game is blocked on the margin, the attack direction and places between the players change.
	45'		Junior game aiming tasks for the official game
Wednesday morning	60'		Recovery
	90'	Medium-High	Training compensation - gymnastics with emphasis on muscle lengthening, stretching, etc.; -motility exercises based on balance (no force elements); - training with technical content (in groups of 2,3,4 players); tactical games in groups of 2vs2, 3vs3, 2vs4, 4vs4, 3vs5 (made up of couples and functional groups, as occur during the game); - all games are conducted using specific compulsory tasks
	45'		2X6 minute slow running. Recovery
Wednesday afternoon	90'	Medium	Individualizing Training - PFS Program using the ball - exercises to improve motility (with and without a ball); - exercises to improve the head game; - exercises to improve completion (by means of optimal sequences in the game, specific team combinations);
	45'		Recovery
Thursday	90'-110'	Medium-High	- Tactical Training - practice - repetition of the game phases through task games on limited areas (basic and secondary) in groups of 6vs3, 6vs4, 8vs6; - Group game on half of the field in groups of 8vs8 (2x10 ", with specific tasks); - improving practice at fixed phases (simultaneous

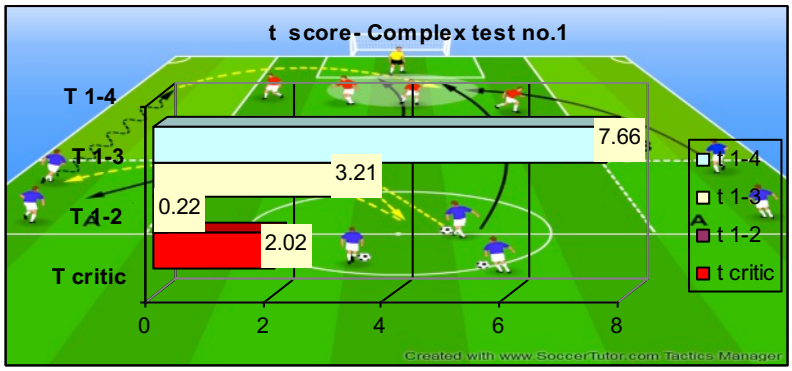
			attack - defense). **Four against three with the mention that the fourth forward player is passive, he will not move from the crossing area only when the ball is passed to him and a crossing will be executed, parallel to the 16 m line, the getaway with the ball shall be done upon the signal of the coach in the midfield, upon the starting of the attack phase, the defenders take their role seriously;** 
Thursday	**90'-110'**	**Medium-high**	**At a 30 m distance from the goal, it shall be delineated a lane on the field's width, made up of cone range poles, having a square type structure of 10 m sides each, at the first signal of the coach, it shall be started the passing of the ball in al the three squares, being counted previously as teams by 1, 2 and 3, passing the ball will be done without setting it first and on the second signal of the coach.**
	60'		**Recovery**
Friday morning	**60'**	**Medium**	**Training for maintaining muscle tone** **- PFS program, motility + balance (30');** **- Game on small spaces (half of the filed) in 2RX10'**
	45'		**Recovery**
Friday afternoon	**60'**		**- Training session for the game (including individual and collective discussions** **- Relaxing program**
Saturday	**30+90'**		**Official game**
	45-60'		**Recovery**

Analysis, processing and interpretation of the data issued upon the completion of the practical experiment - Test – Complex test no. 1

Table no. 1. – Analysis of the statistical indicators for the test – Complex test no.1

	TESTING1	TESTING 2	TESTING 3	TESTING 4	COMPARATIVE ANALYSIS
X	28,25	28,2	27,8	27,1	
S	0,88	1,03	1,19	0,316	
CV	3,13	3,66	4,307	1,166	
Statistical indicators		T 1-2	T 1-3	T 1-4	
Means' difference		0,05	0,45	1,15	
Mean error		0,03	0,0025	0,0025	
t critical		2,02	2,02	2,02	
t calculated		0,22	3,21	7,66	
p		0,07	0,001	0,001	

In the *complex test no. 1* , we may interpret that upon the processing of the results between the two testing, the means' difference does not show a significant increase of the results, t calculated being rated at 0,22 inferior to the t critical for the threshold of 0,05 that we determined. This fact that we are ascertaining may be due to the content of the programs we proposed, which did not aim primarily at this parameter in the first part of the proposed programs. We may notice that between testing 1-3 and 1-4 is seen a significant increasing tendency of the initial level with a significance of the thresholds registered of 0,001, which shows that in this period the content of the programs proposed by us, was more effective than the first period. All this evolution of the results registered in this test specific to field players, may show us that, depending on the training period covered, it is useful to monitor and develop it by specific means and a corresponding dosage, a fact found within our experiment in the content of the training programs proposed. The evolution of the significance during the periods we tested may be presented as well by the graphic showing us the score of t-calculated by us and the score of t- critical that we find in Fischer's table on threshold of 0,05.



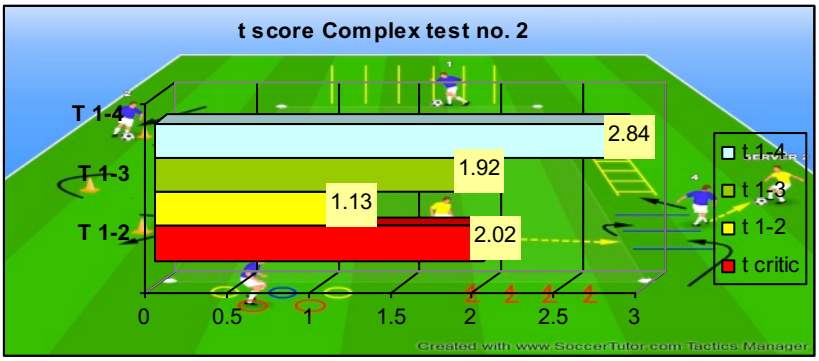
Graphic no 1. – Analysis of the statistic indicators for test–Complex test no. 1

Test – Complex test no. 2

Table no. 2. – Analysis of the statistical indicators for the test—Complex test no. 2

	TESTING 1	TESTING 2	TESTING 3	TESTING 4	COMPARATIVE ANALYSIS
X	54,58	53,9	53,23	52,73	
S	3,02	2,36	3,207	2,808	
CV	5,53	4,38	6,02	5,32	
Statistical indicators		T 1-2	T 1-3	T 1-4	
Means' difference		0,68	1,35	1,85	
Mean error		0,14	0,26	0,2	
t critical		2,02	2,02	2,02	
t calculated		1,13	1,92	2,84	
p		0,09	0,07	0,005	

For *complex test no. 2* we may interpret that upon the processing of the results between the first two testing, the means' difference does not show us a significant increase of the results, the t calculated having a score of 1,13 inferior to the t critical for the threshold of 0,05 that we determined. This fact that we are ascertaining may be due to the content of the programs we proposed, which did not aim primarily at this parameter in the first part of the proposed. We may notice that in between testing 1- 3 as well is seen an insignificant increasing tendency of the initial level with a significance of the thresholds registered of 0,07, respectively which shows that in this period the content of the programs we proposed did not register a higher effectiveness like the first period.



Graphic no. 2. – Analysis of the statistical indicators for test– Complex test no. 2

Conclusions:

- In order to accomplish the specific physical training programs with and without the ball, there have been carried out previously, as a guiding source patterns of: (annual plan, regular training plan, weekly microstructure of training and specific physical training programs in the four periods, preparing, precompetition, competition and of transition)
- The administering of the alternate specific physical training programs contributed to the improvement in the technical tactical play capacity, by the tactical conduct approached by the players, the level of the technical executions, a fact confirmed upon the accomplishment of the game tasks and implicitly of the performance related objectives.

- The objectives of the specific physical training at the age of U18 youth footballers (17 -18 years old) have been created in the training programs, have been determined for each period of time, so that it would determine its accomplishment at superior quality standards in order to favour its manifestation under optimum conditions in the competition period.
- We envisage that the update of the assessment system of U18 youth players in football, concerning the indicators of the specific physical training with and without the ball allows us to arrive at a feedback of the activity of planning – administering- assessing, having as a result the improvement of the technical tactical game capacity and implicitly, the entire activity.
- In order to estimate exactly the level of specific physical training of the athletes submitted to experiments, there have been administered control tests for the segments involved in the carry out of the specific movements*: lower limbs* (genuflections, long jump, vertical jump – détente, sprint running specific to football, maintaining the ball in place, maintaining the ball from movement, complex test 1 and 2) , *upper limbs* (push ups, pull ups in the arms, the specific test for goalkeepers 1 and 2) Also, there have been administered control tests for the estimation of the functional capacity (recumbent position Pulse and orthostatism, blood pressure, Ruffer Test, the Sergent test) and of the somatic capacity;
- The assessment aimed at the performance related conduct for each position in the game, the estimation of the level of specific physical training in the beginning of the experimental program, as well as upon the administering of the training programs, the exact determination of the dosing of the actuating systems;

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DEVELOPMENT OF A STRATEGY TO OPTIMIZE THE METHODOLOGY OF TEACHING - LEARNING - EVALUATION OF SWIMMING TECHNIQUE AT THE JUNIOR LEVEL

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Summary

Teaching teaching, s.f. The act of surrendering and its result. - V. teaches. (after DEX, 1998)

Learning, lessons, s.f. The action of learning and its result; instruction, teaching, study, learned. - V. learn. (after DEX, 1998)

Evaluation is the process by which judgments are made on the results of the measurements, judgments that take into account certain criteria and which at the same time represent the purpose of the measurement. (Epuran, M., 2005).

Keywords: teaching, learning, assessment

Introduction

Technical training is the set of technical knowledge (in our case, the general basics of sports swimming technique) that someone has. (after DEX, 1998).

The use of video media in support of the optimization and perfection of the execution technique of sports swimming procedures is a vast research topic that has interested a large number of specialists in the field of sports performance.

The extent and speed of the changes recorded in the last two decades in performance sports have no equivalent to other comparable periods in the history of this field. The sporting performance in swimming has unleashed creative energies, engaged and realized great spiritual and material forces, becoming, quite literally, a social phenomenon, which is reflected, among other things, in the breaking of numerous world records in a very short time especially at the last Olympic Games in Tokyo 2020 with a higher number than the Olympic Games in Paris 2024.

The impressive, downright astounding value jumps, the huge progress achieved in the last 4 years, constitute an indisputable achievement, richly illustrated by sports performances that only yesterday were considered as the limits of human possibility. The performances will certainly not stop here. In the continuous struggle for breaking records, by a few tenths, hundredths, or even thousandths of a second, the training of athletes, sports training - in all their complexity have acquired and will acquire with each passing hour a more and more pronounced scientific-technical character. All present and future achievements were and will be possible as a result of the fact that the science of physical education and sport has permanently enriched its theory, methodology and practice with conquests and novelties, as well as with those from the adjacent sciences - biochemistry, physiology, biomechanics, informatics, psychology, etc.

Otherwise, the ever deeper and more multilateral intervention of "science" in the organization and development of the content of physical education and sport, of the training process of performance athletes is and will be the only guarantee of achieving new sports performances.

But in addition to all this, along with the increase in the efficiency of different methods and means of training, the continuous improvement of the organization and the conditions for carrying out the sports activity of training and competition of the means of support, restoration and recovery, a contribution, which will soon become indispensable, brought by "television", visual means that offer new, multiple, great and always new possibilities for scientific investigation, so necessary and mandatory for the progress of our field.

The purpose of the research

The acceleration of informational, technical, scientific and social progress is a permanent problem of our days and, related to it, it is increasingly imperative to emphasize the resolution of the relationship between necessity and reality.

I aimed to highlight the importance of carrying out the activity of teaching - learning - evaluation of swimming technique based on global, operational projects and learning units, involving in the training of performance swimmers new training methods, using modern means and techniques , resulting in the improvement of the technique of the movements specific to the sports swimming procedures as well as the motor skills specific to the swimmers. The computer-based approach to modeling training strategies is the concrete, practical way in which, based on the information collected through video capture, and processed with the help of specialized software programs, we can intervene and contribute through our methodological approach to obtaining exceptional sports results.

The premises of the research

One of the problems that I believe to be essential and that the vast majority of coaches neglect, is that more attention is paid to the volume and intensity of the training and the side that involves the technical training of the swimmers is neglected.

The dropout of athletes who reach the threshold of the junior I category is very high, that's why I consider that the junior II period represents the active support of the development of swimmers, and the involvement of research in the improvement of training strategies is a mandatory condition.

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Research objectives

1. Current specific methodological concepts (and new principles) used in the practice of teaching, learning and evaluating the swimming technique of groups of children and juniors;
2. Studying ways and means of optimizing the above-mentioned didactic activities (teaching - learning - evaluation);
3. Rethinking and restructuring the methodology of teaching, learning and evaluating swimming technique by involving new instruments and measurement techniques;
4. Knowing the main characteristics that influence the technique of sports swimming procedures.

Research hypotheses

1. Given that sports teaching technology has been enriched with numerous concepts extrapolated from other sciences (ergonomics, cybernetics, electronics, praxiology, pedagogy, etc.), with numerous tools (methods and techniques) for knowledge of phenomena as well as devices and technical materials able to ensure the objectification of the training process, we believe that under the auspices of these innovations, the activities of teaching - learning - evaluation of swimming technique must be rethought and restructured.

2. We believe that in the methodology of teaching - learning - evaluating the swimming technique, two important moments are distinguished:
- the moment of correct learning and perfecting the dynamic stereotype;
- the moment of continuous improvement of the swimming technique by using all devices and techniques able to identify the parameters and indicators of a biological (including motor) and psychological nature that can be modified during the training process or that provide scientific assistance for the teaching-improvement activities – evaluation

Research methods and techniques

Studying specialized literature.

The method of observation (scientific observation that is: theoretically grounded, systematic and integral, analytical, methodical, conducted according to rules, repeated and verified). Endowed today with the most modern technical means of recording and sorting data, observation remains a method of ascertainment on the basis of which classifications are often made, conclusions are formulated.

The method of measurement and evaluation.

The measurement through the process of assigning numbers to the properties of different phenomena, according to certain rules, represents relevant relationships between them. Evaluation is the process by which judgments are made on the results of the measurements, judgments that take into account certain criteria and which at the same time represent the purpose of the measurement.

The goals and principles of measurement:

a. establishing the status, progress or performances, by using parameters specific to sports swimming such as:

♣ arm cycle frequency (F)
♣ travel speed m/s (v)
♣ distance covered in one arm cycle (DPC)
♣ propulsion index (Ip)

b. classification into homogeneous groups, based on previous performances;

c. motivation – test results can be used to develop intrinsic research motivation;

d. maintaining the anticipated standard;

e. research guidance.

Video recording method - Video capture was made using a Sanyo Xacti E1 submersible digital video camera, following a well-established methodology. The underwater frames were taken from the frontal and lateral plane, from a distance of 2.5 m from the athlete, and the frames captured above the water were also executed from the frontal and lateral plane but at a distance of 5.5 m.

The experimental method. Within this method, the pilot experiment represents a preliminary experiment through which the work technique is verified. This type of experiment is related to the exploratory one and results from the need to confirm the accuracy of experimental reasoning in the verification of a hypothesis;

The use of video recordings in the process of developing mental image formation techniques

One of the difficult problems in perfecting sports techniques is the development of the initial plan or the formation of an image of the execution of the initial element or the formation of an image of the execution of the technical element, before its actual execution. The long effort of learning by trial and error, the repeated instructions from the coach, the countless hours spent in developing a correct mental plan, imagining the perfect execution, are often frustrating. The problem lies mainly in fixing the correct plan, and not the less successful movements, respectively, in capturing the perfect technical element and fixing it in the mind, so that the athlete can continue to practice it mentally and put it into practice. A useful method in this regard is to record on film or

video tape that small number of perfect movements that can be played later whenever necessary. Several sports psychologists have resorted to recording the execution of various technical elements. The editing of the film was done carefully, in consultation with a coach or the athlete in question, aiming to identify the perfect movements. The respective movements were then reproduced on film or tape several times, being shown to the athlete in several consecutive sessions

The viewing of the correct execution was done in the same conditions of relaxed attention that are also recommended for perfecting the techniques of forming mental images. After repeated viewings, the athlete was asked to close his eyes and mentally represent the image. With the advent of portable and easy-to-edit video cameras, image-based techniques have become a very promising tool and within everyone's reach. However, we must not forget that the key element is the kinesthetic perception and not the visual one. Because of this, the method will only be effective if the athlete's observation of the movement helps him experience the kinesthesia associated with the movement he is mentally practicing. The techniques of forming mental images are important not only in focusing on the correct execution but in increasing the awareness of possible errors. The techniques of forming mental images are an extremely useful tool in correcting mistakes, contributing to the mental fixation of correct executions.

"Videofeedback" application situation

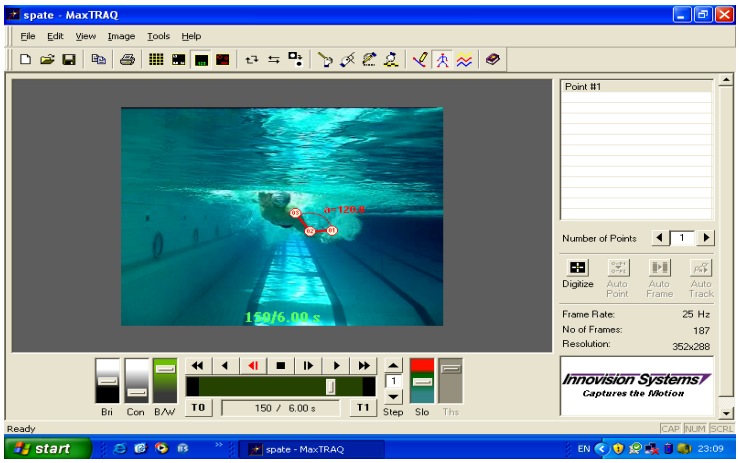
Starting from various theoretical findings, this special situation presents special requirements for video technology: In video-training procedures, the time intervals must have an optimal duration (60 sec.). This is also valid for the interval from the end of the movement to the video-feedback as well as to the next execution sample. The realization of this requirement is dependent on certain organizational and technical conditions. We can point once again to the possibility of extending this interval through internal processes of repetition, ensured by the individual power of giving. However, it results in the necessity within a particularly short interval (60 sec.) to call on the information of a selected image and the possibility of presenting it in an appropriate form, on the spot, in the training unit. Before each video-feedback, the athlete should evaluate his previous execution of the movement, oriented and related to certain characteristics. All other activities, especially those extraneous to the content and uncontrolled, on the contrary, restrict the learning process and must be eliminated during the video training.

The athlete's self-evaluation will be appreciated by the coach in relation to the motor performance achieved. The coach must also be freed from technical decision-making processes, in order to be able to provide the athlete, within the established time frame, with the information and corrections resulting from the observations. Ideally, his activity should be limited to marking the lane and selecting an execution variant already specified before training.

When presenting feedback, there are differences between the current value and the perspective value, which must be adequately explained video-graphically or at least verbally characterized by the coach. Presenting the current value without commenting and without being related to the perspective value is, especially for beginners, rather harmful than stimulating. The program used in our research is MaxTRAQ produced by Innovision Systems Corporation from the USA, a software program specialized in motion analysis, a module with a special attitude for high performance. It is a perfect means in the technical training of swimmers, offering new dimensions to scientific research.

This program is designed two versions: MaxTRAQ 2D and MaxTRAQ 3D.

FIG.1 MAXTRAQ Software Program



The program is able to analyze video captures in MPEG or AVI format, made according to a well-established methodology in order to highlight the most important moments of the technical elements specific to sports swimming procedures. The video capture is processed manually according to the objectives proposed at the beginning of the research, data processing being performed with relative ease. The MaxTRAQ program is an inexpensive and easy-to-use solution. This program is highlighted more with the help of the MaxMATE software program that performs the analysis of the data processed by Max TRAQ.

After making the underwater video captures in digital format, the mixes were made for the analysis of the movement of working with the arms, an approach carried out with the help of the MaxTRAQ software program, and in which the angle of maximum flexion of the elbow during the aquatic path was mainly followed.

Example of a training program structured by learning units: Table no. 1.

Lerning unit no.1				
Theme name	**Objectives/ Competences**	**Content**	**Dosage**	**Forms of evaluation**
T1	Craul: correcting the movement with the arms	► Slide the collar with the support of the legs on the float or float, with a breath in each arm	3x200m p. 30sec.	DPC Video feedback
T2	Craul: correcting the movement with the arms	► Gliding the collar, rowing with only one arm, with two-arm breathing - change the execution arm every 50m	2x300m p. 30sec.	DPC Video feedback
T3	Craul: correcting the movement with the arms	► Slide the collar with breathing in each arm and passing the palm under the armpit	2x300m p.30sec.	DPC Video feedback
T4	Craul: correcting the	► Gliding the neck with the execution of the aquatic route	8x50m p.	DPC Video feedback

	movement with the arms	without performing the aerial route, the arms returning to the position of gliding through the water	25sec.	
T5	Craul: correcting the movement with the arms	► Slide the neck with breath to each arm exercise performed with small palmar for the fingers	3x200m p.30sec.	DPC Video feedback
T6	Craul: correcting the movement with the arms	► I swim backstroke 25m with a clenched fist, 25m with an open palm.	8x50m p.25sec.	DPC Video feedback

Table No. 2. Parametres recorded and video analyzed- Initial

T. I. S.1.	**The best performance50m (timp)**	**Test starting from water 50m (timp)**	**Number of arm cycles 50m**	**Average speed (V m/s)**	**Distance on one arm cycle (DPC m)**	**Propulsion index (Ip = V x DPC)**
Crawl	**26,80**	**28,15**	**32**	**1,77**	**1,56**	**2,761**
Back	**30,43**	**31,05**	**34**	**1,61**	**1,47**	**2,366**
Breast stroke	**35,26**	**36,91**	**26**	**1,35**	**1,92**	**2,592**
Butter flay	**28,40**	**29,95**	**30**	**1,67**	**1,66**	**2,772**

Comparative analysis of the indicators recorded and analyzed through the video technique, initially and finally

Table No. 3. Parametres recorded and video analyzed- Final

T. F. S.1.	**The best performance 50m (timp)**	**Test starting from water 50m (timp)**	**Number of arm cycles 50m**	**Average speed (V m/s)**	**Distance on one arm cycle (DPC m)**	**Propulsion index (Ip = V x DPC)**
Crawl	**25,49**	**27,06**	**30**	**1,70**	**1,52**	**2,679**
Back	**30,50**	**30,55**	**31**	**1,56**	**1,44**	**2,324**
Beasts troke	**34,26**	**35,01**	**26**	**1,28**	**1,78**	**2,278**
Butter flay	**26,40**	**29,25**	**28**	**1,60**	**1,66**	**2,456**

Conclusions:

1. We largely confirm the first hypothesis which claims that the traditional teaching-learning-evaluation activities of swimming techniques can be structured and rethought, in this sense, a first attempt to modernize the sequence process is centered on the focus of teaching activities - learning - evaluation according to the model of the praxeological circuit in which the

instructional objectives are those that condition the other operations of the didactic design.: resource concern; ensuring training conditions; the development and application of instructional strategies; evaluation of the proposed instructional objectives or evaluation of the expected result.

This praxiological circuit formed by O.C.S.M., constitutes the generative act of promoting the quality of efficiency in the training of performance athletes in general and in the teaching - learning - evaluation of sports swimming technique, in particular.

2. Another conclusion refers to the way to proceed in the methodology of developing some curricular products such as: the global training projects and the actual learning units.

As for the global projects, in the new conceptual context, they resemble to a great extent the traditional annual plans. However, in order to distinguish between these two documents, we claim that, in performance sports and especially in the teaching of technique, the following fundamental operations must be defined:

• establishing the instructional contents deduced from the competition performance behavior model;
• establishing the contents by delimiting training units (groups of lessons focused on objectives);
• establishing the real time allocated to the training and carried out in a frontal, group and individual relationship.

As for the learning units, they are similar to classic training programs, only that each of the assigned group of lessons can be done with other exercises or content. However, we highlight three distinct elements:

• instructional objectives expressed in performance behavior, observable and measurable;
• contents made up of operational structures (exercises) that focus on the proposed instructional objectives;
• the test or test to evaluate the achievement of the operational objectives, which actually ensures the quality and efficiency of the training process.

3. We consider that the second hypothesis is also demonstrated, considering that, in the preliminary study carried out by us, we came to the conclusion that the methodology of teaching - learning - evaluating the swimming technique is carried out in two distinct moments:

• the moment of correct learning and the formation of the dynamic stereotype;
• the moment of using all the operations and techniques for identifying the technical behavior.

In this sense, the "moment of continuous improvement" was realized by us through the methods of modeling the competition technique. Thus, each individual athlete was subjected to observation and objective analysis with a view to competition behavior in which corrections, improvements and improvements were made to the observed parameters.

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METHODS TO STIMULATE PUPILS' PARTICIPATION IN PHYSICAL EDUCATION CLASS

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Abstract

The poor attendance of pupils at the PE class was an intensely debated topic in recent years. To poor attendance was added another negative factor, the Covid pandemic, which aggravated this situation due to the total or partial interruption of physical activity (so motor acquisitions were lost or stagnated, children's weight increased, their bodies grew without proper stimulation from a neuromuscular point of view). In this context participation in the PE class, after the pandemic, followed a downward course. The third aspect that influences pupils in this period is technology. Instant access to the Internet, social networks, online games or real-time communication apps captures the attention of children and keeps them away from physical activity. The contemporary PE teacher can be overwhelmed by all these aspects and there is a risk of abandoning professionalism, enthusiasm and creativity in teaching the lessons. Considering that special situations require special measures, this paperwork aims to present solutions from other countries and to generate some methods by which pupils can be stimulated to actively participate in PE classes.

The methods can be from the simplest: the power of personal example; adapting the fundamental part of the lesson according to the children's preferences; eliminating bullying related to the body or motor skills. To a more complex ones: apps for monitoring effort; including team building activities in PE class or transforming the school into a movement friendly zone.

Keywords: PE involvement, pupils, physical activity, variety

Introduction

The present paper work aim is to highlite the obstacles for participating in PE class and more important to present some appliable methods for participating in PE class. The exemples are simple and easy to reproduce in any romanian school.

Barriers to physical activity promotion in schools

There are a number of commonly cited barriers to PA promotion in the school setting. These may be broadly categorized as:

- institutional (concerning school policies, facilities and administrative support),
- teacher-related (arising from the teachers' beliefs and skills) or
- student-related (relating to the student population)

Promoting physical activity in schools can face several barriers, ranging from systemic issues to individual attitudes. Addressing these barriers requires a multifaceted approach, including advocating for increased funding, integrating physical activity into the broader curriculum, providing professional development for teachers, and fostering a positive culture around physical activity both at school and at home.

1. **Lack of Funding** - Schools often face budget constraints that limit the resources available for physical education (PE). This can lead to insufficient equipment, poorly maintained facilities, and a lack of trained PE teachers.
2. **Limited Time in Curriculum** - With increasing academic pressures, PE classes often receive less time in the school schedule. Schools may prioritize core academic subjects over physical education, reducing the time students have for physical activity.
3. **Inadequate Facilities or Equipment** - Many schools do not have adequate facilities such as gyms, playgrounds, or sports fields. This lack of infrastructure can make it difficult to

provide a variety of physical activities that engage all students. Infrastructure can refer to sport related equipment (leaders, cones, balls, etc), facilities (changing rooms, swimming pool, athletic tracks, sport field, etc) and sport related comfort (air conditioning, etc)

4. **Safety Concerns** - Concerns about student safety can limit the types of physical activities offered. Fear of injuries or accidents can lead to **more restrictive and less engaging PE programs.**
5. **Teacher Training and Attitudes** – Maybe one of the most influential barriers. Not all teachers may be adequately trained in delivering effective and engaging PE lessons. Additionally, some teachers may not prioritize PE or may lack enthusiasm, which can negatively impact students' attitudes toward physical activity.
6. **Student Attitudes and Motivation** - Students' attitudes toward physical activity can be influenced by previous experiences, self-confidence, and interest in sports. Those who have had negative experiences or feel fearfull about their physical abilities may be less inclined to participate. Also family context can incline the balance to or away from physical activities.
7. **Cultural and Socioeconomic Barriers** - Cultural attitudes towards physical activity and sports can vary, and some students may come from backgrounds where physical activity is not emphasized. This aspect is getting more actual in Romania through the actual global context (with ucranian migrants after war situation, with multicultural ethnics people migrating here in search for a job – from Asia, Middle Est countries, Africa or even South America). In Romania we have an important aflux of migrants: 50.000 (in 2021), 286.500 (in 2022), aprox. 140.443 (in 2023) conform www.romania.europalibera.org. Socioeconomic factors can also play a role, with students from lower-income families potentially having less access to extracurricular sports and fitness opportunities.
8. **Weather and Environmental Factors** - In regions with extreme weather conditions, outdoor physical activities can be limited, which reduces opportunities for students to be active. Schools without indoor facilities may find it challenging to provide consistent PE programs all year-round. In this climate change periods it became difficult to play sports in hot gyms or sports halls.
9. **Social media usage** has also been correlated with poor adolescent wellbeing, decrements in body image and poorer mental health - ***The Lifestyle Habits of Health Influencer Followers***, published in the Journal of Psychosocial Research, was a cross-sectional study of 1,022 18 to 25-year-olds across New Zealand, the US and the UK, who completed a survey in 2021 about their lifestyle habits, including measures of social media usage, dietary and exercise habits and mental health. Results showed that health **influencer followers reported more vigorous exercise**, higher fruit and vegetable intake and better well-being, **but also greater distress – depression, anxiety and negative mood, compared to non-followers.** Influencers are often perceived as more credible, trustworthy, knowledgeable, authentic and attractive than traditional messaging channels, which might make them more effective in health behaviour engagement.

   Possible harms identified with health influencers include reinforcing the fit ideal and presenting unrealistic body images, which are both associated with increased body dissatisfaction, depressive symptoms and compulsive levels of exercise and obsession with particular diets. The report says: ***"use of visual platforms like Instagram may be particularly harmful to mental health because they focus on appearance, which drives social comparison and negative body image."***
10. **Parental Attitudes and Involvement** - Parents' attitudes toward physical activity can influence their children's participation. **If parents do not value or encourage physical activity, students may be less likely to engage in PE classes or extracurricular sports.**
11. **Policy and Administrative Support** - Lack of support from school administrators and policymakers can hinder the promotion of physical activity. Without a strong emphasis on

the importance of PE from leadership, initiatives to increase physical activity may lack the necessary backing and resources.

Observing the situation from a multi facet perspective involve: a higher rate of absenteism, a post Covid-19 reluctance to sport activities, a lack of resources for PE class and a true „assault" at kids attention from digital devices (tv, telephone, online games, social media, etc.) in this context I find useful to present the findings from a meta analisys done in all european contries.

Good practices examples: in schools and extracurricular strategies adopted by Europeans countries in order to promote physical activites (published in JOURNAL OF HUMAN SPORT & EXERCISE; *Physical education status in European schools*; D'Anna et al., 2019)

Country	School strategies	Extracurricular strategies
Austria	**"Fit Sports Network Austria"** The objective is to strengthen the promotion of P.A. for health within sports facilities and integrate a daily P.A. activity lesson into school programs, guided by local sports clubs and qualified coaches.	
Belgium	Sport Flanders leads a project in which schools can request financial support to open their sports infrastructure after school hours, on weekends and during holidays.	**Sport after school pass (Sport na school pass)** offers after-school sports at affordable prices for all secondary school students, with the aim of increasing their participation in sport, especially for those who are inactive.
Croatia	**Polygon for P.A. of schoolchildren** It is a set of mobile equipment composed of 25 elements that are easy to assemble and disassemble, to support teachers in the providing P.E. and to meet the needs of students.	The goal of the national health promotion program, **"Healthy Living"** is to create conditions in all counties that allow all citizens to reach the recommended levels of P.A. For children, activities are regularly organized in the parks during their free time.
Cyprus	**"All different - all equal"** is a program led by the Ministry of Education and Culture in collaboration with the Cyprus Football Association. A component are school tournaments to increase opportunities for P.A.	**Run for my health (2018)** a great running event for secondary school students organized by the Ministry of Education and Culture, with the aim of motivating schoolchildren to increase their P.A outside school hours.
Czech Republic	**Tell me your story** A campaign for schools and sports clubs aimed at rom children and children at risk of social exclusion. Sports tournaments and competitions of various disciplines have been organized, of which ping pong, athletics and ball games have been the most popular.	**Ride2sCool** is a registered association whose main purpose is to guarantee, maintain and further develop bicycle accessibility for students in the largest cities in the Czech Republic. The program aims to increase the active trip to school by children between 6 and age 14 and involves university students who act as guides and tutors during the trip to school.
Denmark	**45 minutes of daily P.A. in schools** In addition to P.E. classes, they are required 45 minutes of daily P.A. (about 150 hours / year) in primary and secondary public high schools to improve students' learning, health and well-being.	**The Danish Sports Policy (2016)** guarantees all groups in society the opportunity to participate in sports or P.A.. The policy states that special efforts must be made to involve children, adolescents and adults who are not already involved in organized sports as well as in disabled or vulnerable groups that may have difficulty participating in the traditional settings of sports associations.

Estonia	**Schools in motion** A multicomponent proposal for P.A. in schools, providing active lessons, active transport, physical education lessons, involving all school staff, students and parents in these active solutions.	**Redesigning physical education** Redesign physical education to include the promotion of P.A. throughout life, habits and the motivation to be active. The goal is to increase the health culture of all pupils on P.A.
Finland	**"On the move"** is a government action program launched in 2010 to establish a culture of P.A. in Finnish schools. Active breaks and before and after school activities are key elements.	
France	**Intervention centred on adolescents' P.A. and sedentary behaviour (ICAPS)** it is based on a socio-ecological approach and involves different sectors and types of action, such as motivation towards P.A., encourage social assistance to promote P.A., motivating young people to increase their level of practice providing the environmental conditions for promoting P.A. inside and outside the school, in their free time and in everyday life.	**The "National Plan for sport, health and well-being" (National Sports Santé Bien-Etre)** led by the Ministry of Health and the Ministry of Sports, it is the key national policy to promote P.A..
Germany		**National recommendations for P.A. and the promotion of P.A.** were designed in the context of the national action plan "in the form", the national initiative to promote healthy diets and P.A..

Greece	**Swimming school program** is a program for 8-9 year-olds as a pilot project launched in Athens in 2015 and was later extended throughout Greece, at the national level in 2018. The program is part of each school's P.E. course.	**"Sports for All"** The goal of the program is to offer opportunities for the entire population to be physically active. Includes proposals for people with disabilities, preschool children, adolescents and adults and the elderly in mental health facilities.
Hungary	**Adaptation of the Hungarian national student fitness test (NETFIT®) to children with special educational needs** it is a physical fitness test supported by online software. Test data are used to monitor individual and group changes in the state of physical fitness of students with special educational needs.	In 2015, the Secretary of State for Sport has launched an infrastructure development program called the **National Recreational Sports Park Health Program** Several sports parks have been built according to predefined criteria.
Ireland	**Junior cycle well-being program** The program involves the provision of a minimum of 300 hours in three years of learning opportunities to improve the physical, mental, emotional and social. The program includes P.E., civic education, and social policy and health. The program is mandatory for all post-primary schools in Ireland.	**National Sports Policy 2018-2027** Its three top-level objectives are: greater participation, more excellence and better capacity. An area of particular attention will be to increase the levels of participation in sport and P.A. of the entire population and to restrict existing gradients in gender, age, socio-economic status, disability and ethnicity.
Italy	**Classroom sports** the project goal is to promote P.E. and P.A. in primary schools, with the involvement of students, teachers, school administrators and families.	There are no projects organized by the Ministry but by the various federations that operate at national level for the promotion and dissemination of sports.
Latvia	**Everyone exercises** a project with the aim to strengthen the role of sport in society, to inspire children to engage in regular P.A. and monitor the effects of exercise on their health. In addition to two mandatory P.E. classes per week, three optional lessons are scheduled per week, thus providing daily P.A..	**Since 2017, the Center for Disease Prevention and Control** has conducted interventions to promote P.A. with different objectives: strengthening the muscles involved in posture, teaching correct breathing techniques to children aged 7 and 8 and educating the elderly (≥ 54 years)) in P.A..
Lithuania	"Spring of activeness" The goal of the project is to encourage young adolescents to have physically active lifestyles by offering experiential learning opportunities in informal P.A. based on best practices of other countries.	Lithuania has prepared a national strategy for sports development for the period 2011-2020, which promotes sport for all and is based on four themes: greater awareness of the benefits of P.A.; development of sports skills; development of sports infrastructure; and accessibility of sports infrastructure.

Luxembourg	**Active schools** it is a project to increase P.A. in elementary and primary schools in Luxembourg.	The **"Sports Night" (Nut du Sport)** is a national event launched in 2009. The municipalities are encouraged to offer all people the opportunity to engage in P.A., welcoming and festive places.
Malta	**"Schools OnTheMove"** is a multifaceted and dynamic program to promote and support participation in sport and P.A.. The program includes sessions of P.A., mainly on Saturday mornings, which are open to children aged ≤ 16 years.	The Ministry of Education and Labour promotes sports programs and P.A. for children whose parents cannot afford to send them to class, also helping them in the purchase of specific clothing, footwear and equipment, the cost of which could otherwise prevent participation.
Netherlands	**Learning together, performing well** is a case study of a primary school in The Hague that integrates P.A. and P.E. throughout the curriculum. The school offers 3 hours of P.E. per week, with additional hours for sports such as martial arts, tennis and volleyball. The program also facilitates sports participation during and after school.	
Poland	**School sports clubs** is a program offered to primary and secondary schools to encourage P.A., especially among children and adolescents with poor physical fitness, providing more exercise, under the supervision of a teacher of P.A.. Lessons are held twice a week, for 60 minutes per session, with a minimum of 15 students.	The Ministry of Sport and Tourism activates a program through which it is possible to obtain financing for the construction or modernization of recreational infrastructures such as swimming pools, sports fields and outdoor gyms. The program aims to ensure that each municipality has a normal sized gym and each county has an indoor pool, increasing the overall number of recreational facilities.
Portugal	**CicloExpresso do Oriente (2015)** consists of a group of children accompanied by adults, who make a trip to and from school by bicycle. A sort of "bicycle train" that makes this journey safer and more fun and facilitates greater future autonomy for children and young people.	The **"U-Bike Portugal"** promotes active transportation in academic communities through cycling. The Institute for Mobility and Transport coordinates the project, which hires bicycles for students and staff from academic institutions for a semester or an entire academic year.
Romania	**Community guideline on healthy eating and P.A. in schools and play schools** to foster healthy behaviour among children, for all teachers and other professionals, and propose four essential interventions to guarantee: sufficient P.A., regularly eating breakfast, adequate consumption of fruit and vegetables and drinking only water .	A program of P.A. after school has been prepared to supplement the compulsory school curriculum and to prevent early school leaving, increase academic performance and accelerate learning through educational, recreational and leisure activities as well as personal development and social integration.
Slovakia	**"To school on a bicycle" (2015)** national campaign that encourages elementary school children to go to school by bicycle to increase their daily P.A.. A further national project to improve the qualification of physical education teachers in schools was implemented by the National Sports Center in 2015 with the aim of training teachers to conduct 1-hour P.A. sessions with modern methods and tools.	**The "Grab a ball, not drugs" ("Zober loptu, nie drogy")** The project in force since 2012 and is led by a non-governmental organization. The goal is to involve children and adolescents in team sports in collaboration with 12 sports clubs in Slovakia. It also organizes information and educational campaigns, competitions and other sporting events.
Slovenia	**The surveillance system SLOfit** Since 1987 it is operating a surveillance system in Slovenia "SLOfit" to monitor the physical and motor development of children and adolescents. With the help of SLOFIT, children and their parents can monitor their physical and motor development, and physical education teachers have access to important information to enable children and adolescents with developmental problems for help and professional guidance. SLOFIT also collects information on the nutritional status of children, including body weight.	The national program for nutrition and P.A. that improves health 2015-2025 includes measures to provide opportunities for socially disadvantaged groups to be physically active, including increasing the availability of open green spaces, the organization of sporting activities , promotion of recreational physical in nature and the promotion of active transportation.
Spain	**(Unidades Didacticas Activas (UDAs)),** is an educational material developed by teachers specializing in the subject, aimed at increasing the percentage of intensity of P.A. of moderate to vigorous during physical education classes. **Data on assessment of a healthy physical condition** It is an official system for the community of Galicia, in which professionals in physical and sports activities monitor the physical conditions (physical fitness tests, including aerobic condition and strength) of individuals and groups.	

Fig 1. School and extracurricular strategies adopted by Europeans countries in order to promote physical activites (Source: Physical education status in European schools; D'Anna et al. /published in JOURNAL OF HUMAN SPORT & EXERCISE)- 2019 - Spain

In order to empasieze the ideea of succesful strategies for increasing PE involvment I choose to detail three examples that can be reproduced here in Romania:

1. **STUDY CASE 1**

The Daily Mile is a simple concept with a big impact! We all know the benefits of exercise and the dangers of a sedentary lifestyle, yet childhood obesity is rising and, a stunning statistics (from www.theguardian.com) inform us that **three quarters of children spend less time outside than prison inmates!**

The Daily Mile initiative invites children and staff to go running outside for fifteen minutes every day to experience the physical, emotional and social benefits that exercise brings. It's a non-competitive, inclusive and joyous expression of what children love to do - move!

Wellbeing, mental health and obesity are complex, multi-factoral issues, so there can never be a single solution. However, Elaine Wyllie, founder of **The Daily Mile**, sums up the benefits perfectly, saying "***We take 15 minutes from the curriculum but we give more back in attainment, focus, happiness, health."***

Research conducted by the Universities of Stirling and Edinburgh found that 15 minutes of self-paced exercise can **significantly improve a child's mood, attention and memory, enhancing their ability to learn when they return to the classroom**. In a pilot scheme of The Daily Mile conducted at Coppermill School, London, **children's average fitness percentile result soared from 37% to 64% in just 12 weeks**. An increase in selfesteem and wellbeing was noted, as well as better than expected academic attainment in standardised school tests.

2. **STUDY CASE 2**

The blog **peoffice.co.uk** organized by UK Physical Education teachers offers some tested solutions to increasing participation level in PE classes:

- **OFFER A GREATER VARIETY OF ACTIVITIES**

"For example, if you identify that Year 10 girls are not as keen on team sports, you may be able to raise participation by introducing activities like aerobics to current dance playlists or other activities that you think will appeal more to specific groups.

- **MAKE IT FUN**

The more fun that you can bring into PE lessons, the more students will enjoy them. Find ways to make sections like the warm-up a little bit more fun than just running and stretching by incorporating little games or using different sports equipment. If you follow football, you might have seen the England team preparing in training at the World Cup by swimming with inflatable pink unicorns. Part of the reason was to relax the players but by making sessions more fun, it stopped the players from getting bored as they might have done with general training methods. Music can add some enjoyment to the PE class also.

- **A PE KIT (clothes) THAT DOESN'T PUT STUDENTS OFF**

There are many factors to consider when developing the PE kit requirements, from the cost to comfort and also incorporating religious clothing requirements. Most **high school students will be going through puberty and may not feel comfortable in tight-fitted clothing** and may have growth spurts to contend with. So, when deciding the PE dress code, it might help to get feedback from a representative sample of students to help address any kit issues that could lead to lower participation. Sliders and designer labels are obviously not going to make the cut but **it does help to get students' opinions!**

- **PROMOTE POSITIVE ROLE MODELS**

Having positive role models to aspire to be can help combat a variety of different reasons behind lower participation levels. For example, girls who think that certain sports are not very feminine might be encouraged by seeing role models from the sport. **This could be by showing videos, or it**

could be by inviting guests into the school to talk to students. If you find that some students don't want to participate in sports because it isn't seen to be cool (or whatever the latest teen lingo is) then talking about sports stars with similar backgrounds to the students might inspire them (a local boxer, a well know dancer or a swimming champion who went on to be successful, for example).

- **ASK STUDENTS WHAT THEY WANT TO DO**

Whilst you might get some ridiculous answers if you ask students what they would like to do in PE lessons, you might also get some valuable insight into what will appeal to them more. Even if you only take one student-suggested lesson a term, it will help them to feel more involved and engaged in PE.

- **BREAK UP THE DAY WITH A MOVEMENT BREAK**

Sitting for long periods can be draining for students. Combat this by incorporating short movement breaks throughout the day. Simple stretches, jumping jacks, or even classroom yoga poses can re-energise students and improve focus.

- **CELEBRATE EFFORT AND MAKE IT A COMMUNITY EFFORT**

Focus on the joy of movement and celebrate effort over athletic ability. Organize school-wide events like walk-a-thons or colour runs. Encourage teachers and staff to participate alongside students to create a sense of community and shared purpose. You can be original and organize mixt teams (boys and girls), different number of players in basketball game (3x3; 4x4; 5x5).

- **INVOLVE PARENTS AND THE COMMUNITY**

Parents play a crucial role in encouraging healthy habits. Work with them to promote physical activity at home and **invite them to participate in school events.** Community partnerships with sports clubs or fitness centres can also offer additional resources and activities.

- **MAKE YOUR SCHOOL A MOVEMENT-FRIENDLY ZONE**

Is your school environment encouraging physical activity? Consider creating walking paths, installing active play equipment during recess, or even incorporating designated movement zones within the building. These small changes can make a big difference in how much students move throughout the day."

3. **STUDY CASE 3**

The LRPE program (Learning Readiness P.E.)

This program was developed in Naperville District (USA) by Paul Zientarski a PE teacher at local highschool, show that since the inception of the program, s**tudents who participated in LRPE increased their literacy and math capabilities.** The LRPE program emphasizes the importance of staying active and uses a variety of facilities to encourage that—such as climbing walls, kayaks, ropes courses, dance rooms, and weight training; it isn't your average gym. More exceptional than the P.E. resources is how Zientarski has applied current scientific knowledge to his program. Neuroscience research shows that the more fit a student is, the better his or her academic performance. Therefore, every P.E. class includes a cardio work out of some kind for at least twenty minutes, coupled with the use of heart rate monitors to ensure that students are reaching their targeted heart rate zones. The district has also ensured that their students understand the emphasis they place on fitness and wellness. As Zientarski says, "Since we understand how exercise helps the brain function, we want to make sure that the high school students understand how and why it helps them academically." Another huge focus of LRPE is foregoing larger teamed sport games for small-sided games (i.e. 4 on 4 soccer) instead—the goal, after all, is to have students engaging in more moderate to vigorous physical activity.

In the mid-1980s, Zientarski and the Naperville District Coordinator, Phil Lawler, began to brainstorm ways they could improve their P.E. curriculum. Zientarski and Lawler had a vision of collective professional development that quickly grew into a one day conference held in DuPage County for P.E., Health, and Driver's Education teachers. The annual conference is recognized nationally and averages an astonishing 1200+ attendees. The Path to Change Heart rate monitors

were the first investment the school made in enhancing P.E., money for which came from a local fundraiser. District P.E. coordinator Lawler recognized that when his students played regular gym sports like football, they were not reaching their targeted heart rate. ***"These monitors really gave us the evidence that things needed to change, and now we have Pass Ball, a form of ultimate Frisbee with a football that requires students to spend a lot more time running."*** said Zientarski. These changes didn't come without resistance; students who were typically seen as athletic realized that they also had to put work into their P.E. class to maintain their targeted heart rate zone, which vary from student to student based on their personal fitness. The administration's support of the P.E. department was instrumental in securing the school's Carol White Physical Education Program grant that funded a new climbing wall and ropes courses. The LRPE curriculum, which was developed by Lawler and Zientarski in house, aligns P.E. class with a student's specific learning needs, for instance, by scheduling P.E. before math or reading class for low performing students. Technology like heart rate monitors and TriFit software, used for data collection and analysis, has been used extensively in Naperville. "***Physical education is more than a few baseball bats and basketballs. You need to arm physical education teachers with the proper technology, like heart rate monitors and software to track their students' fitness***," Zientarski said. The benefits of PE program for academic results (algebra) can be observed in Fig. 2.

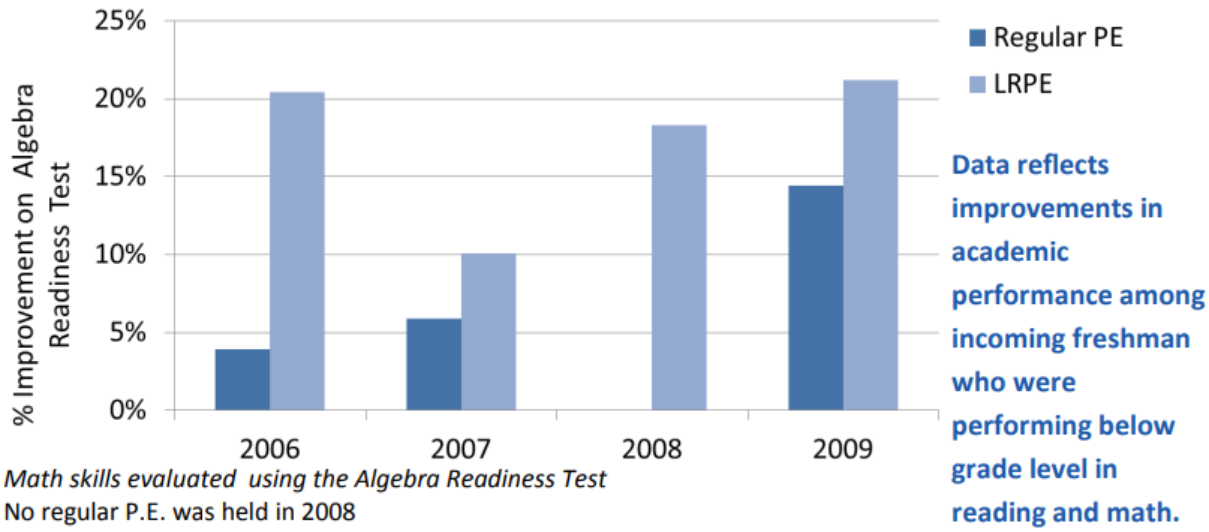

Figure 2 The results at math tests after participating in LRPE curriculum.
(Source: https://iphionline.org/wp-content/uploads/2020/01/P.E._Case_Study_Naperville.pdf)

Zientarski and the Naperville administration recognized early on that LRPE helps students academically (Figure 2). Naperville Central employs FITNESSGRAM® software so that both teachers and students can track individual fitness progress. The success of Naperville's LRPE program is largely due to the community of supportive parents. Zientarski specifically attributes the visit Dr. John Ratey, professor of psychiatry at Harvard Medical School who first conceptualized LRPE, to the publicity that created awareness and ongoing support from the community. Although Zientarski and Lawler are now retired, the current P.E. coordinator Neil Duncan continues their legacy.

Results

Solutions derived from my practical activity, from the discussions with the parents of the pupils and from the debates organized with the students of the Faculty of Physical Education, Sport and Kinetic Therapy of the Romanian-American University regarding influencing the pupils to participate in the physical education class.

1. Individual/personalized progress monitoring. Thanks to the extremely easy access to effort monitoring devices and thanks to digitization (which will be implemented in the PE class) **pupils can observe their personal progress** (they manage to do 25 abdominal flexions, compared to the 15 they managed at the beginning of the semester).

The student can request a report in which he can see how he stands at a certain sports test, compared to: 1. The average of his class; 2. School average; 3. The best result of the school; 4. The record for the region or even for the country, 5. His own past performance; etc

2. **Organization of short extracurricular trips.** They must satisfy several requirements: It should be close to the students' location (maximum 30-40 minutes), it should take place in safe spaces, possibly arranged (forests path, parks, sports grounds, Adventure Parks for example) and involve other family members too (siblings, parents, grandparents, etc.). The duration of activity does not need to exceed 3-4 hours (especially for younger children).
3. **Equipping the school with devices/instruments to encourage movement outside of PE class.** The design of the school can focus on these elements that are mounted outside the gym. Some examples, which must meet security and efficiency standards:

- Table tennis tables (placed in such a way as not to disturb)
- 3x3 basketball boards (requires little space)
- Small climbing routes (**Photo 1-2**)
- Balance beams (Photo 3)
- Technical routes (adjustable) (photos 4-5)

Photo 1-2 Physical activities outside sport hall
(Source: https://www.climbingwallsolutions.com/traverse-climbing-walls-for-schools/)

Photo 3-4-5 Physical activities outside sport hall (Source: https://issuu.com/gametimeplayground/docs/2024outdoorfitnessbrochure_issuu)

4.Teacher Training and Engagement. Provide training for all teachers **(not only PE teachers)** on the **importance of physical activity and how to integrate movement into their lessons**. Teachers can serve as role models by participating in and encouraging physical activity. Also they will avoid to change a PE class for a more "important" chemistry class (to recover "the lost material").

5. Walking and Biking Routes. Encourage walking or biking to school by providing secure bike racks and organizing "walking school buses" or "bike trains." This promotes physical activity before and after school hours and socialization in pupils. A safe route, bike designated, will be preferred.

6. **Monitoring preferences for physical activities**. Currently, an online questionnaire, sent by phone, is easy to create and administer by PE teachers. Pupils can present their personal options, they can make useful suggestions, explanations can be found for their reluctance for some activities (at football, girls are "afraid" of getting injured; at dances, boys are afraid of looking "embarrassing", for example). The teacher who can have the synthesis of the results from entire school, will be able to adapt the program more efficiently, will know what materials to order and will have more success with his PE class.

7. Organizing a "Sport Week" for sport activities. Following the succes of "**green week"** – when kids are encouraged to participate in ecological activities and "**different week**" when kids are encouraged to participate in different activities than curricular – trips, visits, traditional activities, etc. the Sport Week can be a distinct period or, preferably, included in those other two events. Another option will be in the period of Ski holiday (when not more than 20% of romanian kids go to the slopes).

Sport Week – it was a suggestion of one student at Kinesiology class at the R.A.University in order to influence kids involvement in physical activities and participation in PE class. **The idea was to have a period of 4-5 days in which all the sport clubs, gyms, tennis facilities, judo clubs, volleyball teams and many other forms of physical activities to present their offer (kind on Open Gate Day) and the kids can try all this sports and choose one or two for practice.** The parents can meet the coaches and have their questions answered, the kids can bring their friends over and sport clubs will have more clients (so we can have a so call win-win-win situation).

Discussion and Conclusions

All this solution presented, starting with the European countries policy, the best three practices and the seven suggestions applicable in Romania will provide a usefull set of solution for the romanian PE teacher in his quest to offer an efficient, fun and consecvent participation at his PE class.

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PROGRAMA DE INTERVENCIÓN EN HABILIDADES PARA LA VIDA Y ESTILO DE VIDA ACTIVO EN UNIVERSITARIOS (HHVEVAU): RESULTADOS CUALITATIVOS PRELIMINARES

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Resumen

La salud mental óptima, entendida como el estado de bienestar en el que una persona es consciente de sus capacidades cognitivas, capaz de afrontar las tensiones normales del día a día, realizar tareas académicas de manera productiva y participar activamente en su comunidad. El objetivo de este estudio fue diseñar e implementar un programa de intervención de 11 semanas de intervención sobre habilidades para la vida y estilo de vida activo (Programa HHVEVAU), siguiendo las pautas del informe Transparente de Evaluación con Diseños No Aleatorios (TREND), para la adquisición de habilidades intrapersonales e interpersonales en estudiantes universitarios. La muestra estudo compuesta de 27 estudiantes de 18 a 25 años (M = 20,05; DT = 1,8) (18 mujeres y 9 hombres) organizados en un grupo de intervención (GI) (N = 18) y un grupo control (N = 8) (GC) (no realizaron el programa de intevención) (N = 8; 4 mujeres y 4 hombres). El estudio concluye con datos cualitativos (respuesta de una entrevista semiestructurada) sobre la percepción satisfactoria de los estudiantes universitarios en relación a la regulación emocional, las cogniciones, comportameintos nutriconal y conducta de ejercicio físico en el desarrollo académico. Son necesarios otros datos de tipo cuentitativo (respuesta a test psicométricos) y pruebas de aptitud física que confirmen los efectos positivos del programa multicomponente HHVEVAU en estudiantes universitarios.

Palabras clave: intelegencia emocional, psiconutrición, ejercicio físico, salud integral, jóvenes universitarios.

1. INTRODUCCIÓN

La presente propuesta de investigación se centra en la importancia de formar y acompañar a jóvenes estudiantes universitarios en las habilidades para la vida y estilo de vida saludable a nivel físico y psicológico. Con el propósito de que disfruten de un adecuado desarrollo personal, académico, e incluso profesional en un futuro próximo. Uno de los valores esenciales para el verdadero desarrollo personal en los individuos es la "sabiduría", entendida como el grado de aprendizaje asociado al desarrollo personal y de aspectos transpersonales como la autorregulación emocional, la resiliencia, el respeto a uno mismo y a los demás, la responsabilidad personal y social (Wright & Burton, 2008). En este trabajo se describe el diseño y el modo de implementación del programa de intervención "HHVEVAU, Habilidades para la Vida y Estilo de Vida Activo" en estudiantes universitarios, desde un abordaje integral de las dimensiones de desarrollo del ser humano, basándose para ello en teorías psicológicas que explican el comportamiento humano. Paradigmas teóricos que analiza los procesos cognitivos y emocionales de la motivación enlos individuos (Reeve, 2012), el Modelo Transcontextual de la Motivación (MTM) (Hagger y Chatzisarantis, 2009b) y el Modelo Biopsicosocial de la actividad física (Bauman et al., 2012). Se evidencia la interconexión entre: a) el nivel de motivación personal, b) la motivación experimentada por la persona en los diferentes contextos en los que se desarrolla (MTM), c) la satisfacción de las Necesidades Psicológicas Básicas (NPB, Echegoyén et al., 2022), d) la adquisición de habilidades intra- e interpersonales (Goleman, 1995), e) la "alfabetización motriz" (integración de conocimientos, procedimientos, actitudes y emociones vinculadas a la conducta motriz), así como, la mejora de la condición física (Raymond et al., 2022).

Otras de las acciones biopsicosociales y académicas que fundamentan la presente propuesta, se centra en la alineación de los objetivos del programa HHVEVA con los pilares del Modelo Académico (MA) de la Universidad Europea (UE). El MA se establece de forma híbrida (presencial y online) exigiendo al docente poseer, mejorar y adquirir nuevas competencias sociopedagógicas en estos dos contextos en conjunción con las competencias digitales y tecnológicas (He et al., 2023). Asimismo, y en línea con la última evidencia científica en pedagogía, cada vez más universidades, incluida la UE, están actualizando su MA para fomentar el aprendizaje experiencial.

1.1. Objetivo e hipótesis

Según lo expuesto, este trabajo se estructura en dos objetivos principales: 1) diseñar un programa de intervención (Programa HHVEVAU) basado en el conocimiento y manejo de las habilidades intrapersonales (inteligencia emocional), la regulación emocional de la conducta alimentaria y la práctica regular de ejercicio físico, para la promoción de un estilo de vida más saludable en estudiantes universitarios; 2) implementar el programa de intervención "HHVEVAU" a través de varias sesiones de psicoeducación, de talleres de psiconutrición y de entrenamiento dinámico de la fuerza. Se hipotetiza que el programa HHVEVA producirá un impacto positivo sobre la salud psicoemocional, física y social en estudiantes universitarios.

2. MATERIAL y MÉTODOS

2.1. Diseño de investigación

Se trata de un diseño de protocolo metodológico de un programa educativo intervencionista (pre-post). En este diseño se ha empleado *Template for Intervention Description and Replication* (TIDieR) (Hoffmann et al., 2014). La metodología empleada para la recogida datos es de tipo cuantitativa y de diseño pre-post intervención con comparación de datos intra-sujeto e intersujeto.

2.2. Participantes

La muestra estuvo integrada por 27 estudiantes de 18 a 25 años (M = 20,05; DT = 1,8) (18 mujeres y 9 hombres) organizados en un grupo de intervención (GI) (N = 18) y un grupo control (N = 8) (GC) (no realizaron el programa de intevención) (N = 8; 4 mujeres y 4 hombres). Se trata de estudiantes de grado (1° y 4º) de Ciencias de la Actividad Física y del Deporte, de Fisioterapia e Ingienería de la Universidad Europea de Madrid (UEM). Ambos grupos serían evaluados en dos momentos (pre-intervención y post-intervención) por medio de cuestionarios psicométricos, test antropométricos y test de condición física.

2.2.1. Reclutamiento de la muestra

Los estudiantes fueron reclutados empleando la técnica de difusión de carteles colocados en diversos espacios físicos y virtuales de la UEM. El cartel incluía un código "QR" vinculado con un cuestionario elaborado en "Google forms" para la inscripción a la sesión informativa previa al inicio del estudio. Para participar en el estudio, debían cumplir los criterios de inclusión detallados en la tabla 1. La técnica de muestreo aplicada fue no probabilística por conveniencia (Ozten & Manterola, 2017).

Tabla 1. *Criterios de inclusión e inclusión de la muestra.*

Criterios de inclusión	Criterios de exclusión
Ser estudiantes universitarios de grado mayores de 18 años y hasta 29 años.	Estudiantes menores de 18 años y mayores de 29 años.
Comprometerse a participar al 90% de las sesiones de intervención .	Asistencia menor al 90% de las sesiones de forma presencial.
No tener patología metabólica, mental y anatómico-funcional diagnosticada y con contraindicaciones para la práctica de ejercicio físico.	No haber completado todas las pruebas de la recogida de datos antes y después de la intervención.

2.3. Variables e Intrumentos de recogida de datos cualitativos

Se describen las variables objeto de estudio cualitativo y la técnica empleada para la recopilación de las mismas.

Instrumentos de recogida de datos cualitativos

Se ha elaborado una *Entrevista semiestruturada* (Ibarra-Saíz et al., 2023) de 6 preguntas de respuesta abierta para conocer la percepción de los participantes acerca del impacto personal a nivel emocional, psiconutricional y físico del programa de intervención HHEVAU. La última pregunta hace referencia a la transferencia de la experiencia vivida en el estudio a otras áreas de su vida. Se presentan a continuación los ítems/preguntas de la entrevista ad hoc:

1) ¿En qué aspectos emocionales de tu vida universitaria te ha ayudado el programa HHVEVAU?

2) ¿Qué comportamientos sientes que son diferentes en ti tras la participación en el programa HHVEVAU?

3) ¿Qué nuevos pensamientos "favorables" han surgido en ti a la hora de afrontar los exámenes u otras pruebas de evaluación tras la participación en el programa HHVEVAU?

4) ¿Qué cambios/modificaciones has implementado a nivel nutricional y qué te han aportado en el afrontamiento de los retos académicos tras la participación en el programa HHVEVAU?

5) ¿Qué tipo y frecuencia de ejercicio físico has incluido semanalmente tras la participación en el programa HHVEVAU?

6) ¿Qué transferencia crees que tiene el programa HHVEVAU en tu vida fuera de la universidad.

2.3.3. Variable independiente

El programa de intervención HHVEVA (Habilidades para la Vida y Estilo de Vida Activo). Se propone el diseño de un programa intervencionista educativo multicomponente (intevención psicoeducativa, nutricional y en ejercicio físico) de 11 semanas de duración.

3.1. Fases del diseño del programa HHVEVAU

Se presentan las fases del diseño del programa HHVEVAU en relación con el primer objetivo del presente estudio.

El programa HHVEVAU fue creado en tres fases que se describen en la tabla 2. En relación con los profesionales responsables del programa, éste ha sido diseñado por tres investigadoras de la UEM, dos de ellas doctoras en CCAFyD (Ciencias de la AF y del Deporte), una de ellas doctorada en Psicopedagogía. Además, de una cuarta integrante, estudiante de 4º grado de CCAFyD que contribuyó en el diseño y puesta en marcha de las sesiones de entrenamiento dinámico de la fuerza, como parte de la asignatura de "prácticas externas". Para el diseño e implementación de los talleres de psiconutrición, se contó con el asesoramiento y colaboración de una nutricionista (estudiante de doctorado) experta en prevención de trastornos del comportamiento alimentario.

Tabla 2. *Fases del diseño del programa HHVEVA.*

	Fase 1	Fase 2	Fase 3
Acciones	1) Aprobación del Comité ético de la UEM. 2) Diseño de la metodología de investigación: - estado de la cuestión, - preguntas de investigación, - Planteamiento de los objetivos e hipótesis.	3) Diseño de las sesiones de intervención: - 8 sesiones de psicoeducación aplicada al desempeño académico (60 min./sesión). - 8 sesiones de entrenamiento dinámico de la fuerza (50 min./sesión). 3 talleres de psiconutrición (60min./sesión).	4) Reclutamiento de la muestra y selección de espacios y materiales (cuestionarios y pruebas física). 5) Sesión informativa previo inicio del estudio. 6) Inicio del programa de intervención la 2ª semana de abril de 2024. El miércoles de esta semana se realizó la 1ª sesión de psicoeducación y la 1ª sesión de entrenamiento físico. 7) Fidelización del programa.

En la tabla 3 se describen los tipos de sesiones, los contenidos, los objetivos y el paradigma teórico en el que se fundamenta el diseño del programa HHVEVAU.

Tabla 3. *Sesiones, contenidos, objetivos y paradigma teórico para la implementación del programa HHVEVA.*

Tipo sesiones	Sesión/Contenidos	Objetivos
Psicoeducación	Sesión 1. Salud integral	Conocer el significado de "salud mental".
	Sesión 2. Emociones y retos académicos	Examinar las emociones derivadas de los retos académicos.
	Sesión 3. Conflictos emocionales	Poner en práctica la resolución de casos prácticos sobre conflictos emocionales personales y sociales.
	Sesión 4. Diálogo interno	Tomar conciencia de los pensamientos asociados a las emociones y su conexión con el cuerpo.
	Sesión 5. Parentalización	Explorar sobre los modelos de crianza y cómo condicionan nuestras reacciones.
	Sesión 6. El guión de vida, los mandatos y las posiciones existenciales	Profundizar sobre el propio guión de vida tomando conciencia de el los mandatos que se han recibido en la infancia.
	Sesión 7. Los juegos psicológicos	Realizar identificación y desarrollo de los juegos psicológicos.
	Sesión 8. Poniendo límites y aprendiendo a comunicar	Trabajar supuestos prácticos para establecer una comunicación sociafectiva adecuada, previniendo los juegos psicológicos.
	Sesión 8. Asertividad personal	Abordar diferentes formas de "lenguaje verbal y no verbal" en la toma de decisiones diarias en el ámbito académico.
	Sesión 9. Habilidades interpersonales	Identificar y desarrollar formas de comunicación emocional, lenguaje verbal y no verbal en ela relación con los compañeros y los docentes.

	Sesión 10. Herramientas para transitar las emociones en momentos de estrés academico	Desarrollar herramientas psicológicas y comportamentales para afrontar los desafíos cognitivos, emocionales de los exámenes, trabajos final de grado, trabajos final de máster.
	Sesión 11. Puesta en común los contenidos y prácticas de las sesiones anteriores	Revisar y recopilar todos los conceptos psicológicos, emocionales, comportamentales trabajados durante las 10 sesiones anteriores.
Talleres de psiconutrición	Taller 1. Grupos de alimentos y forma de nutrirnos	Conocer lo grupos de alimentos y cómo regular las ingestas diarias.
	Taller 2. Regulación emocional de la conducta alimentaria	Examinar la relación entre emoción y forma de comer.
	Taller 3. Retos académicos y alimentación	Desarrollar ejemplos de comidas para un mejor desempeño académico.
	Taller 4. Elaboración de menús sencillo y saludables en época de exámenes.	Diseño y preparación de menús saludables y sostenibles en cuanto al tipo de alimentos, cantidades recomendadas y el cocinado (técnica culinaria sencilla).
Sesiones de entrenamiento Supervisadas por entrenadora	Sesión 1. Reeducación postural y Bracing	Transmitir las técnicas de ejercicio físico y la respuesta fisiológica y emocional asociada, a través de la reeducación postural y trabajo abdominal "Bracing".
	Sesión 2. Movilidad y Fuerza Tren Inferior	Comenzar trabajo de movilidad integral y fuerza de miembros inferiores con el propio peso corporal.
	Sesión 3. Movilidad y Fuerza Tren Superior	Desarrollar trabajo de movilidad integral y fuerza de miembros superiores con el propio peso corporal.
	Sesión 4. Iniciación a la escalada	Poner en marcha el trabajo transversal de psicoeducación "4. Diálogo Interno" y la práctica de escalada.
	Sesión 5. Fuerza de hemisferio corporal inferior (miembros inferiores)	Realizar trabajo de fuerza de miembros inferiores con material (peso libre y fitball).
	Sesión 6. Fuerza de hemisferio corporal superior (miembros superiores)	Continuar trabajo de fuerza de miembros superiores con material (peso libre).
	Sesión 7. Fuerza	Avanzar trabajo de fuerza de miembros inferiores con variación de carga (kg. Y velocidad ejecución).
	Sesión 8. Fuerza "Full Body"	Conseguir la máxima implicación muscular y coordinación intermuscular en ejercicios compuestos y secuenciales.
	Sesión 9. Fuerza de hemisferio corporal inferior (miembros inferiores)	Realizar trabajo de fuerza de miembros inferiores con material (peso libre, bandas de suspensión, squat, ..).
	Sesión 10. Fuerza de hemisferio corporal superior (miembros superiores)	Continuar con el trabajo de fuerza de miembros inferiores con variación de carga (kg., velocidad de ejecución, nuevos ejercicos [experimentar con ejercicios en diferentes planos de movimiento]).
	Sesión 11. Global Circuint tranning	Desarrollar un entrenamiento "full body" en forma de circuito, alternando ejercicios fuerza de miembros superior e inferiores.

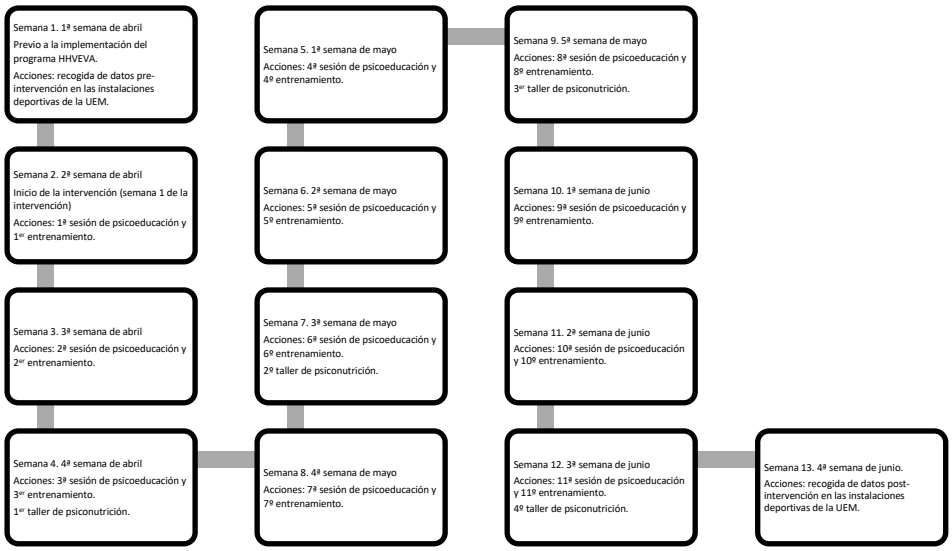
3.2. Implementación del programa HHVEVAU

En la figura 1 se describen las acciones de implementación del programa de intervención. Previo a la implementación del programa HHVEVAU, la 1ª semana de abril de 2024, se procedió con la toma de datos pre-intervención de las variables objeto de estudio a través de los instrumentos descritos en el apartado 2.3. Se citaron a los participantes (en parejas) para asistir al laboratorio de entrenamiento de la UEM en el que se realizaron los test de fuerza en función de la velocidad (sentadilla y press de banca), antropometría, medición de perímetros. La prueba de resistencia de esprines repetidos se hizo en la pista de atletismo. En la tabla 4 se muestra la secuencia de recogida de datos pre-intervención (la 1ª semana de abril, miércoles y jueves).

Una vez recogidos los datos pre-intervención, la 2ª semana de abril de 2024 tuvo lugar el inicio de la implementación del programa HHVEVAU. El programa tuvo una duración de 11 semanas de intervención en las que se desarrollaron 11 sesiones de psicoeducativas, 11 entrenamientos presenciales supervisados por una profesional del entrenamiento personalizado y 4 talleres de

psicoeducación. Toas las sesiones del programa de intervención estaban focalizadas en el abordaje de la dimensión cognitiva, emocional, comportamental y social del estudiantado universitario.

Figura 1. *Cronograma de la implementación y recogida de datos pre-post-intervención del programa HHVEVAU.*



4. Resultados

Resultados cualitativos preliminares reclutados a través de entrevista semiestructurada. A continuación, se presentan las respuestas literales recogidas de algunos de los participantes durante las primeras

Preguntas	Ejemplos de dos respuestas literales a las preguntas planteadas
1) ¿En qué aspectos emocionales de tu vida universitaria te ha ayudado el programa HHVEVAU?	- Respuesta 1. *Siento que ya no me presiono tanto cuando tengo que hacer un examen.* - Respuesta 2. *Siento menos ansiedad. Incluso estoy menos irritable.*
2) ¿Qué comportamientos sientes que son diferentes en ti tras la participación en el programa HHVEVAU?	Respuesta 1. *Siempre estaba preocupado y ahora soy capas de organizar de forma prioritaria las actividades y tareas académicas*. - Respuesta 2. *Estoy menos ansiosa con la comida por las tardes. Ya sé que cuando no desayuno bien, por la tarde me lo comería todo. Es un alivio tener recursos emocionales y alimentarios para afrontar los periodos de estrés por los exámenes*.
3) ¿Qué nuevos pensamientos "favorables" han surgido en ti a la hora de afrontar los exámenes u otras pruebas de evaluación tras la participación en el programa HHVEVAU?	- Respuesta 1. *Ahora me repito con más frecuencia que "soy capaz".* - Respuesta 2. *Me doy cuenta de "los pensamientos saboteadores" y en mi mente suena la frase: "lo estás haciendo bien".*
4) ¿Qué cambios/modificaciones has implementado a nivel nutricional y qué te han aportado en el afrontamiento de los retos académicos tras la participación en el programa HHVEVAU?	- Respuesta 1. *No me olvido de desayunar y llevo un snack saludable de los que vimos en uno de los talleres para no pasar tantas horas sin comer desde el desayuno hasta el almuerzo.* - Respuesta 2. *Antes de irme a una opción dulce me digo: ¿de verdad lo necesitas o es*

	ansiedad por los exámenes? Sé elegir mejor qué comer.
5) ¿Qué tipo y frecuencia de ejercicio físico has incluido semanalmente tras la participación en el programa HHVEVAU?	- Respuesta 1. *Necesito moverme y sentirme activa porque me ayuda a despejar la mente. Me he apuntado a clases dirigidas de step.* - Respuesta 2. *Le he cogido el gusto a las sentadillas y al ejercicio físico al aire libre. He vuelto a probar la escala que inicios en una de las sesiones de psicología que se combinó con esta práctica deportiva.*
6) ¿Qué transferencia crees que tiene el programa HHVEVAU en tu vida fuera de la universidad.	- Respuesta 1. *Creo que mucha porque mi familia me dice que me ven más serena. Yo siento que puedo con los trabajos/prácticas diarias, me canso menos.* - Respuesta 2. *Ahora disfruto más de la actividad física con los compañeros y de tener momentos para el descanso mental y conectar con mi cuerpo.*

5. DISCUSIÓN

El presente estudio tuvo como objetivo exponer el diseño e implementación de un programa intervencionista (Programa HHVEVA, "habilidades para la vida y estilo de vida activo") como estrategia para la adquisición de habilidades de regulación emocional, habilidades sociales y desarrollo de una vida activa a nivel físico en estudiantes. Esta propuesta se centra en que la salud mental es esencial para una buena calidad de vida, y está estrechamente relacionada con la salud física. Las patologías de salud mental son trastornos que afectan el pensamiento, el estado de ánimo y el comportamiento de una persona. Pueden ser causadas por una combinación de factores genéticos, biológicos, ambientales y psicológicos, siendo muy debilitantes y pudiendo afectar a la capacidad de una persona para trabajar, estudiar, mantener relaciones interpersonales y cuidar de sí misma.

Se ha planteado un estudio con diseño de metodología mixta (cuanti-cuali) cuasi-experimental (pre-test y pos-test), con grupo experimental (GE) y grupo control (GC) no aleatorizados. Es fundamental poder replicar y mejorar el programa de intervención a lo largo del tiempo y en diversos contextos universitarios de ámbito nacional e internacional.

En relación con los programas de intervención en educación superior, existen propuestas de intervención diseñadas para ayudar a los estudiantes universitarios con problemas de salud mental, o bien sin ellos, pero con la finalidad de cuidar este aspecto y mejorar la calidad de vida de los universitarios. Por ejemplo, encontramos estudios recientes que se centran en la mejora de la empatía mediante el desarrollo de la inteligencia emocional (Barqueros-López et al., 2019), la mejora del estrés y las estrategias asertivas o la sabiduría personal (Arteaga-Checa et al., 2022). A su vez, hay diversas teorías que se han estudiado desde hace años con estudiantes universitarios las terapias relacionadas con la teoría cognitivo-conductual (Stice et al., 2009).

La propuesta presentada facilita a los participantes herramientas prácticas que puedan implementar para mejorar sus habilidades intra e interpersonales (salud mental) en conjunción con su salud física, mejorando así su autonomía en la consecución y mantenimiento de su salud integral.

6. CONCLUSIONES

Se concluye que el diseño del programa de intervención "HHVEVA" ha integrado el desarrollo del enfoque psicológico, la regulación emocional de la conducta alimentaria, de la conducta de ejercicio físico y las relaciones interpersonales en estudiantes universitarios.

La implementación del programa de intervención "HHVEVA" ha permitido a los estudiantes universitarios ser conscientes de sus cogniciones, sus emociones y la mejora de la condición física

para el afrontamiento de los retos académicos. Todo ello, con el fin de promover el bienestar emocional, la resiliencia y la calidad de vida de los estudiantes.

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POSSIBLE LEGAL CONSEQUENCES OF SPORTING ACCIDENTS

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Abstract

This paper aims to review essential aspects regarding the potential legal consequences of sports accidents by analyzing data from specialized literature in sports and legal sciences, with direct applicability to sports accidents.

The study addresses the factors that can contribute to sports accidents, categorizes these accidents by severity, and outlines the general circumstances that are legally recognized as potential causes of such incidents. It also examines the domains in which the consequences of sports accidents may manifest, including the athlete's health, sports activity, social environment, and legal sphere.

The paper emphasizes the various types of legal consequences of sports accidents—civil, criminal, contractual, and insurance-related—making specific references to Romanian criminal and civil legislation applicable to these incidents. Additionally, it outlines the general steps to be followed in the event of a sports accident.

The purpose of this work is to promote a better understanding of liability in sports accidents, identifying who can be held accountable and under what conditions. This understanding aims to foster a more effective approach to the challenges faced by athletes, coaches, venue managers, and spectators alike.

Key words: *sports accidents, civil liability, criminal liability, sports insurance*

Introduction

A sports accident is an unforeseen event that occurs suddenly during a sports activity, resulting in morphological (structural) or functional changes in the athlete's body. These incidents can occur in both amateur and professional sports *(What is a sports injury?, 2014)*.

Statistics collected from various groups of athletes across different countries, including our own, indicate that the relative frequency of sports accidents ranges between 1–3% of the total number of individuals participating in sports activities *(Defining the Term "Overuse", 2018)*.

The risks associated with sports are diverse, ranging from minor to severe, depending on factors such as the type of sport practiced, the level of performance, the quality and appropriateness of sports equipment, the use of sport-specific protective gear, and the individual physical, mental, and health characteristics of the athlete. Sports injuries are common and can vary significantly in severity, from minor ailments to serious, even fatal, incidents.

Such unforeseen events can lead to complex legal situations. Therefore, understanding who might be held responsible and knowing what steps to take following a sports injury are crucial. This knowledge can help all parties involved—athletes, coaches, venue managers, and spectators – to adopt a more effective approach to addressing the challenges that arise.

1. The Factors That Could Favor the Occurrence of Sports Accidents

Preventing sports accidents is only possible if the underlying causes are known.

The factors that may contribute to sports accidents can be classified into two categories:

1.1 Extrinsic Factors (Unrelated to the Athlete)

1.2 Intrinsic Factors (Related to the Athlete's Physical and Mental Characteristics)

1.1. The Main Extrinsic Factors:

a) Training Errors:
- Failure to properly train.
- Lack of proper credentials or certification.
- Inadequate supervision.
- Insufficient conditioning.
- Inadequate preparation.

b) Weather Conditions:
- High humidity.
- Extreme temperatures.
- Strong winds.
- Low visibility.

c) Training or Competition Ground:
- Improper design or poor maintenance of playing fields or premises.
- Insufficient preparation of landing sites (e.g., athletics, gymnastics).
- Uneven or overly hard ground (e.g., athletics, sports games).

d) Choosing Inappropriate Routes:
- For activities like skiing, cycling, or cross-country skiing.

e) Equipment:
- Improper equipment or poor fitting.
- Inadequate equipment.
- Use of inappropriate materials.
- Lack of protective equipment.
- Failure to wear protective equipment.

f) Materials and Devices:
- Poor quality of materials or devices (e.g., parallel bars, rings, poles, trampolines, etc.).
- Equipment that is inappropriately sized or weighted for age and gender (e.g., gymnastics equipment, weights, discs, fences in athletics, balls in sports games).

g) Incorrect Nutrition:
- Poor dietary habits affecting the athlete's health and performance.

h) External Psychological Factors:
- Psychological stress, anxiety, or external pressures that may impact performance.

i) Opponent:
- Differences in skill, weight, or height (e.g., unequal matching of opponents in wrestling, judo, boxing, karate, volleyball, tennis).
- Deviations from sports discipline and ethics by opponents.

j) Organization of Lessons, Training, and Competitions:
- Poor organization of lessons, training sessions or competitions.
- Unorganized movement of participants and spectators.
- Non-compliance with the instructions given by event organizers.

k) Risk Factors Specific to Certain Sports:
- Failure to warn participants about the inherent risks involved in certain sports.

l) Deficiencies in the Athlete's Medical Assistance:
- Failure to properly observe, refer, or stabilize an injured athlete.
- Improper return-to-play decisions.
- Inadequate screening or physical examinations.
- Failure to enact proper rules to prevent injuries resulting from sports accidents.
- Lack of an emergency medical plan.
- Medical malpractice.
- Improper medical clearance for return to play.

m) Referees:
- Failure to stop or curtail risky or violent behavior during competition.

1.2. The Main Intrinsic Factors:

a) Incorrect Technique:

- In various sports such as boxing, athletics, gymnastics, skiing, etc.

b) Fatigue:

- Both acute and chronic fatigue can increase the risk of injury.

c) Doping:

- The use of performance-enhancing drugs can compromise the athlete's physical condition and coordination.

d) Malalignment/Anatomical Variations:

- Misalignment of bones, joints, or muscles that may predispose an athlete to injury.

e) Discrepancies in Limb Length:

- Differences in the length of the lower limbs may cause imbalance or excessive strain on certain muscles or joints.

f) Muscle Imbalances:

- An imbalance between opposing muscle groups can lead to injury.

g) Muscles with Reduced Strength:

- Weak muscles, especially those not sufficiently trained, are more vulnerable to injury.

h) Reduced Flexibility:

- Lack of flexibility can lead to muscle strains or joint injuries.

2) Reduced Neuro-Muscular Skills:

- Inadequate neuromuscular control or coordination can affect performance and increase injury risk.

j) Dysfunctions of the Kinetic Chain:

- Any dysfunction in the kinetic chain (the interconnected system of muscles and joints) can lead to improper movement patterns and injuries.

k) Body Composition:

- Body fat percentage, muscle mass, and overall physical condition can influence injury susceptibility.

l) Sex, Weight, and Age:

- Differences in sex, body weight, and age can impact an athlete's risk of injury due to various factors such as hormonal influences or joint health.

m) Genetic Factors:

- Genetic predisposition may influence the likelihood of certain injuries or conditions.

n) Endocrine Factors:

- Hormonal imbalances or changes can affect an athlete's physical performance and injury risk.

o) Internal Psychological or Mental Factors:

- Psychological stress, anxiety, or mental conditions may affect an athlete's focus, coordination, and overall ability to perform safely.

(https://pregatirefizica.wordpress.com/2015/11/21/accidentele-in-sport/,2015; https://wildwoodlegal.co.uk/sports-injury-claims/,2024)

2. The Severity of Accidents in Sports

Most sports accidents are minor and do not lead to significant consequences.

Depending on the loss of work capacity and the need for specialized medical assistance, accidents are categorized into four groups:

2.1. Group I – Minor Accidents

This group includes accidents in which the individual retains their ability to work. Functional disorders and injuries caused by the accident do not prevent the person from continuing to participate in physical education lessons, training, or sports competitions. Minor accidents typically do not require special medical treatment and usually go unregistered (i.e., they are not included in the statistics on the frequency of sports accidents). Examples include minor contusions, bruises, excoriations, small hematomas, and small wounds.

2.2. Group II – Medium Severity Accidents

This group includes accidents that cause a temporary loss of work capacity but do not require specialized medical care. Functional disorders and injuries from the accident require first aid, treatment, and subsequent medical follow-up. To ensure quick recovery and prevent complications, the injured person must rest, either partially or fully, which prevents participation in physical education lessons, training, or sports

competitions. Treatment can typically be done on an outpatient basis. Common accidents in this group include: sprains (grade I and II); fibrillar muscle strains and tears; some contusions and wounds

2.3. Group III – Serious Accidents

This group includes accidents that result in the loss of work capacity and require hospitalization. Functional disorders and injuries are significant and necessitate prompt and specialized intervention at the accident scene. The injured person must be transported to a hospital for appropriate care, followed by a variable period of physiotherapy for recovery. Examples of accidents in this group include: fractures; some dislocations; third-degree sprains; fascicular and total muscle tears; cranial contusions

2.4. Group IV – Fatal Accidents

This group includes accidents where the injuries and functional disorders are so severe that they result in the death of the victim. Despite urgent and intensive therapeutic intervention, death occurs in these cases. Fatal accidents are rare and are exceptions in the field of physical education and sports. Possible fatal sports accidents include: skull fractures with severe brain contusion; cerebral lacerations; cervical spine fractures with brainstem damage; severe injuries to internal organs (lungs, heart, liver, kidneys, spleen, intestines) with massive internal bleeding (e.g., hemothorax, hemopericardium, hemoperitoneum); serious polytrauma with traumatic and hemorrhagic shock.
(https://pregatirefizica.wordpress.com/2015/11/21/accidentele-in-sport/,2015)

3. The General Judicial Situations That Can Generate Sports Accidents

3.1. Negligence

Negligence is the primary legal basis for liability in many sports accident cases. It is a fundamental legal theory used to establish liability in personal injury cases, including sports injuries. In the context of sports, negligence occurs when a party's failure to act with reasonable care results in harm to another. Several parties can be implicated under this doctrine, including organizers, facility owners, coaches and staff, fellow competitors, and spectators. In negligence claims, the injured party must prove that the defendant owed them a duty of care, breached that duty through action or inaction, and directly caused the injury as a result of the breach.

3.2. Product Liability

Product liability pertains to injuries caused by defective or unsafe sports equipment or products. Manufacturers, distributors, and retailers can be held liable if a participant is injured due to a defect in the product they provided. There are three main types of defects that can lead to liability: design defects; manufacturing defects; failure to warn

In product liability cases, the injured party must demonstrate that the product was defective, they were using it as intended or in a reasonably foreseeable manner when the injury occurred, and that the defect directly caused the injury. When equipment fails due to defects, the responsibility may fall on the manufacturer. Legal recourse for defective equipment involves proving that the equipment was faulty and that this fault caused the injury.

3.3. Intentional Torts

Intentional torts refer to deliberate acts that may result in legal action if a player intentionally harms another. In sports, this could include violent actions or purposeful interference that results in injury, going beyond the ordinary risks associated with the sport.

3.4. Recklessness and Gross Negligence

Recklessness and gross negligence refer to situations where behavior is not necessarily intentional, but the conduct is so careless or extreme that it results in harm. In these cases, the defendant may have acted with disregard for the safety of others, but without the intent to cause injury.

3.5. Assumption of Risk

Participants in sports may waive certain rights by choosing to engage in a risky activity. This doctrine acknowledges that by participating in a sport, individuals implicitly accept certain risks inherent to the activity. However, this does not absolve other parties of all responsibility. The key distinction lies in differentiating between risks that are considered normal to the sport and those that are not.
(https://www.bautistaleroy.com/sports-accidents-and-their-legal-implications, 2022;
https://www.thefafirm.com/blog/sports-injuries-liability-what-you-need-know/,2024;
https://www.akdlawyers.com/personal-injury/sports-injury-liability/, 2024)

4. The Consequences of Sports Accidents

The consequences of sports accidents can manifest on several levels:

4.1. Consequences on the Athlete's Health

Sports accidents can have varying consequences on the athlete's health, ranging from immediate to long-term effects. These may include complications such as infections, embolisms, or abnormal bone healing (e.g., vicious calluses). There can also be sequelae, which are lasting functional or organic disorders resulting from the injury, disease, or surgical interventions. For example, joint pain, capsulo-ligamentous laxity (which exposes the athlete to recurrent dislocations), and muscle atrophy are common long-term consequences.

4.2. Sports Consequences

These consequences directly affect the athlete's sports activity. They can result in a decrease in performance levels, the inability to participate in certain sports competitions, and financial losses for sports clubs or organizations. The athlete may also face difficulties in continuing their training or career.

4.3. Social Consequences

An injury can prevent the athlete from performing their professional duties or attending school. This may negatively impact their personal finances, as they may incur treatment expenses or be unable to work. The athlete's family and social circle can also be negatively affected, both emotionally and materially, due to the consequences of the injury.

4.4. Legal Consequences

Various entities and individuals may be held legally responsible for sports accidents, either criminally or civilly. These include:

- Schools and Educational Institutions
- Sports Coaches and Trainers
- Physical Education Teachers
- Sports Facilities and Equipment Manufacturers
- Sports Leagues and Organizations
- Fellow Athletes
- Event Sponsors and Promoters
- Government Entities
- Healthcare Providers

(https://pregatirefizica.wordpress.com/2015/11/21/accidentele-in-sport/,2015; https://www.bautistaleroy.com/sports-accidents-and-their-legal-implications,2024)

5. Types of Legal Consequences of Sports Accidents

5.1. Criminal Liability

Criminal liability applies in cases where criminal charges are brought, typically when intentional or extremely reckless actions result in severe injury or death.

Intentional misconduct is less common in sports, but there are instances where injuries result from intentional acts. These could include acts of violence during a game or harm intentionally caused by a coach or another player. Such actions go beyond the scope of accepted risks in sports and can lead to criminal repercussions. Violence in sports generally refers to violent, and often unnecessarily harmful, intentional physical acts committed during or motivated by a sports game, especially in contact sports.

When it comes to the players themselves, these acts often involve excessively violent or potentially illegal physical contact that exceeds the normal levels of contact expected in the sport.

Examples of such acts of violence can include:

a) Intentional attempts to injure a player or coach by another player or coach.

b) Physical harm inflicted on players or coaches by fans or spectators.

c) Acts of violence committed by fans or spectators against opposing fans or other spectators.

5.2. Civil Liability

In the civil domain, lawsuits for damages resulting from sports accidents may include compensation for medical expenses, lost wages, and pain and suffering.

What can be recovered from sports injury claims?

There are various types of compensation that can be awarded following a sports accident, provided the injury was not the fault of the person seeking compensation. Some examples of the types of compensation that can be recovered include:

a) Loss of Income

If the injured party was required to take time off work due to their injuries, they should be entitled to recover the loss of earnings for the full period of time they were unable to work.

b) Pain and Suffering

The law acknowledges the trauma and pain associated with sports accidents. Consequently, injured parties may be entitled to compensation for the suffering they endured as a result of the accident.

c) Loss of Amenity

The injured party may be able to claim compensation for their loss of amenity. This refers to instances where the injuries prevent them from participating in activities they once enjoyed. The loss of enjoyment can significantly affect the individual's quality of life and may lead to long-term emotional effects such as frustration or depression. The law provides compensation for any loss of amenity caused by an accident.

d) Other Financial Losses

In addition to the above, other financial losses directly resulting from the accident, such as medical costs, rehabilitation expenses, or travel costs for treatment, can also be recovered as part of a personal injury claim.

How is compensation calculated?

Personal injury compensation is generally made up of two types of damages: general damages and special damages.

a)General Damages

General damages refer to compensation for pain, suffering, and loss of amenity. Judges typically determine the amount of general damages by referencing previous similar cases, alongside guidelines issued to them. The compensation is based on the injuries described by qualified medical professionals.

b) Special Damages

Special damages cover any direct financial losses the injured party has suffered as a result of the accident. These can include loss of earnings up to the settlement, future loss of earnings, and costs related to care provided during recovery.

(Legea nr. 287 privind Codul civil, 2009; Legea nr. 134 privind Codul de procedură civilă, 2015; Legea educației fizice și sportului, 2000)

5.3. Contractual and Insurance Implications

Contracts, waivers, and insurance policies play a significant role in the legal consequences of sports accidents. Personal or liability insurance is essential in mitigating the financial impact for athletes and organizations.

Many sports organizations and facilities carry liability insurance to cover injuries that occur on their premises or during their events. In some cases, injured parties can file claims directly with these insurance providers. However, dealing with insurers can be challenging, and the settlements offered may not fully compensate for the victim's total losses.

Professional athletes often enter into contracts that include waiver and exculpatory clauses, which are designed to limit liability in the event of injury for teams, sponsors, and event organizers. While these provisions can sometimes be enforced by courts, their enforceability can vary. Courts will carefully review them, especially if they are deemed unconscionable or overly broad.

(https://www.bautistaleroy.com/sports-accidents-and-their-legal-implications, 2022)

6. Criminal Consequences of Sports Accidents According to Romanian Legislation

In the Romanian Penal Code, three articles address offenses against bodily integrity or health that may apply following a traumatic sports event:

Art. 193 – Striking or Other Violence

(1) Hitting or any acts of violence causing physical suffering are punishable by imprisonment from 3 months to 2 years or a fine.

(2) The act that causes traumatic injuries or affects a person's health, with the severity assessed by up to 90 days of medical care, is punishable by imprisonment from 6 months to 5 years or a fine.

(3) Criminal action is initiated upon the prior complaint of the injured person.

Art. 194 – Bodily Injury

(1) The act described in Art. 193, which causes: an infirmity; injuries requiring more than 90 days of medical care; serious and permanent aesthetic damage; abortion; endangerment of life.
This is punishable by imprisonment from 2 to 7 years.
(2) If the act was committed with intent to cause any of the consequences above, the penalty is imprisonment from 3 to 10 years.
(3) The attempt to commit such a crime is punishable.

Art. 196 – Bodily Injury Due to Negligence

(1) An act provided under Art. 193 (causing up to 90 days of medical care) committed by fault, under the influence of alcohol or drugs, or during illegal activities, is punishable by imprisonment from 3 months to 1 year or a fine.
(2) An act provided under Art. 194 (causing more than 90 days of medical care) committed by fault is punishable by imprisonment from 6 months to 2 years or a fine.
(3) If the act was committed due to non-compliance with legal or professional standards, the penalty is imprisonment from 6 months to 3 years or a fine.
(4) If the act affects two or more persons, the punishment is increased by one-third.
(5) If the non-compliance with legal standards constitutes a separate crime, the rules on concurrent crimes apply.
(6) Criminal action is initiated upon the prior complaint of the injured person.

There are also two articles addressing crimes resulting in the death of the victim as a result of a sports accident:

Art. 192 – Manslaughter

(1) Manslaughter is punishable by imprisonment from 1 to 5 years.
(2) Manslaughter resulting from non-compliance with legal standards is punishable by imprisonment from 2 to 7 years.
(3) If the act results in the death of two or more persons, the punishment is increased by half.

Art. 195 – Hits or Injuries Causing Death

If the act described in Art. 193 or Art. 194 results in the death of the victim, the penalty is imprisonment from 6 to 12 years.

Additionally, when sports accidents occur in professional settings, criminal charges related to workplace safety may apply:

Art. 349 – Failure to Take Legal Safety and Health Measures at Work

(1) Failure to take legal safety measures that create an imminent risk of accident or disease is punishable by imprisonment from 6 months to 3 years or a fine.
(2) The same offense committed by fault is punishable by imprisonment from 3 months to 1 year or a fine.

Art. 350 – Failure to Comply with Legal Safety and Health Measures at Work

(1) Non-compliance with safety and health obligations that create an imminent risk of accident or disease is punishable by imprisonment from 6 months to 3 years or a fine.
(2) Reinstating machinery or equipment before eliminating deficiencies that caused the stoppage is also punishable by imprisonment from 6 months to 3 years or a fine.
(3) The same offenses committed by fault are punishable by imprisonment from 3 months to 1 year or a fine.
(Legea nr. 286/2009 privind Codul Penal, 2009; Legea nr. 135 privind Codul de procedură penală, 2010)

In these situations, when sports are practiced professionally, the specific procedures for investigating work accidents will be triggered.*(Legea nr. 319, 2006; Norma metodologică, 1996)*

Sports Venue Liability

Sports venues also play a critical role in ensuring safety. Proper maintenance, adequate lighting, and clear signage are essential to preventing accidents. If a venue fails to address issues like broken railings or slippery surfaces, it could be held responsible for resulting injuries and for penil or civil responsibilities.

Spectator Injuries

Spectators can also be injured by flying objects or accidents due to venue conditions. While venues typically install protective barriers and issue warnings, accidents may still occur. Legal accountability for spectator injuries depends on whether the venue's safety measures were adequate and if warnings were clear. If safety measures are insufficient or warnings unclear, the venue might be held liable for spectator injuries.

Conditions for Criminal Liability

For an act to be considered a crime, it must:

- Be defined by criminal law;
- Be committed with guilt (intent or negligence);
- Be imputable to the person who committed it.

Only offenses based on criminal law can establish criminal liability. The applicable law is the law of the place where the sports accident occurred.

(Legea nr. 286/2009 privind Codul Penal, 2009; Legea nr. 135 privind Codul de procedură penală, 2010)

7. Civil Consequences of Sports Accidents According to Romanian Legislation

The civil consequences of sports accidents in Romania are primarily regulated by the **Civil Code**, in **Book V: About Obligations**, **Title II: Sources of Obligations**, **Chapter IV: Civil Liability**, specifically in Articles **1349-1395**, along with other supplementary legal provisions.

Both *tortious civil liability and contractual civil liability* may apply following a sports accident. The key articles that outline these liabilities are as follows:

Art. 1349 – Tort Liability

(1) Every person is required to follow the rules of conduct established by law or local custom and not to harm the rights or legitimate interests of others through their actions or inactions.

(2) Anyone who violates this duty, with discernment, is responsible for all resulting damages and must compensate for them in full.

(3) In specific cases provided by law, a person may be held liable for damages caused by the actions of another, or by things or animals under their care, or the ruin of a building.

(4) Liability for damages caused by defective products is established by special law.

Art. 1350 – Contractual Liability

(1) A person must fulfill the obligations they have contracted.

(2) If they fail to fulfill this duty without justification, they are responsible for the damage caused to the other party and must repair the damage according to the law.

(3) Unless otherwise provided by law, neither party can avoid the application of contractual liability rules to opt for rules more favorable to them.

(Legea nr. 287 privind Codul civil, 2011)

8. Legal Steps to Follow in a Sports Accident

When a sports injury occurs, understanding the necessary legal steps is crucial to ensure proper compensation. Below is a guide to the typical process:

a) File a Personal Injury Claim

The first step is usually to file a personal injury claim against the party, or parties, believed to be at fault for the accident.

b) Gather Evidence

Collect key evidence that can support your case, such as: *photographs* of the injury and the accident scene; *witness statements* from anyone who saw the incident;.*official reports*, including medical records and incident reports. This evidence will help establish the facts of the case.

c) Report to Authorities or Regulatory Bodies

If safety regulations were violated or there are legal obligations to report the accident, it may be necessary to notify authorities or relevant regulatory bodies. This is particularly important in cases involving public venues or professional sports.

d) Communicate with Involved Parties

In some cases, issues can be resolved informally through direct communication with the involved parties. However, it is important to understand the rights and responsibilities of each party before proceeding informally. This includes knowing what liability or negligence each party may hold.

e) Prove Negligence or Liability

The success of the personal injury claim will largely depend on the ability to prove that the defendant(s) were negligent or liable for the injury. Key points to prove may include:

- A duty of care existed.
- The duty was breached (e.g., failure to follow safety rules).

- The breach directly caused the injury.

(https://www.olympiainjurylawyer.com/catastrophic-injuries-in-sports-liability-and-legal-recourse/, (2024), Accesed on November 15, 2024
https://wfirm.com/essential-guide-to-liability-in-sport-injury-cases/, (2024), Accesed on November 15, 2024)

Conclusion

The legal consequences of sports accidents extend across multiple fields, including criminal, civil, contractual, and sports insurance law. These consequences can impact various aspects, such as the athlete's health, their ability to participate in sports, their social environment, and the responsibilities of other parties involved—such as coaches, venue managers, and spectators.

A thorough understanding of who can be held responsible and under what conditions is crucial. It allows for a more informed approach to addressing the challenges that arise in the sports world. Whether as an athlete, coach, venue manager, or spectator, knowing the potential legal ramifications of an accident can foster a safer and more accountable sports culture. This awareness can influence attitudes toward aggression, the importance of safety equipment, and the strict enforcement of rules, ultimately contributing to a safer and more responsible sports environment for all participants.

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ADVANTAGES OF USING DIGITAL TECHNOLOGY IN MAKING CUSTOM ORTHOSES

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Abstract
Technological progress, recorded in many fields of activity, has brought significant changes in the medical field as well. The use of digital technology in the creation of custom orthoses represents an evolution in the medical field. This process ensures a high level of personalization, efficiency and comfort, also contributing to the patient`s quality of life.

Key words: *custom orthoses, 3D scanning, 3D design, 3D printing, milling, advantages*

Introduction

Technological progress, recorded in many fields of activity, has also brought significant changes in the medical field, facilitating the creation of custom orthoses.

"An *orthosis* or *orthotic device* is an appliance applied to the body to stabilize or immobilize a body part, improve alignment, prevent deformities, protect against injury, or assist with motion or function." (Yamane, A., 2019, p. 3)

To make an orthosis, digital technology can be successfully used, including *3D scanning* of the targeted body segment, *3D design* (realization of the digital design of the orthosis) – through CAD (Computer-Aided Design) and *3D printing/milling* of the orthosis – through CAM (Computer-Aided Manufacturing).

Modern scanning technology has transformed the process of designing and manufacturing custom orthoses, increasing the precision and accuracy of making orthotic devices also reducing the time and cost involved.

3D scanning, combined with 3D design, allows finding solutions adapted to the particularities and requirements of each patient, and 3D printing/milling offers a fast and efficient means of manufacturing.

Advantages of using digital technology

3D Scanning is of great importance in the assessment of the patient anatomy and in the design of orthotic devices. Through three-dimensional scanning, accurate images of the targeted body segment are captured, thus allowing the customization of the orthosis.

3D scans are fast, accurate, non-invasive, and can be used both for initial measurements, as well as during the use of the orthosis to make any adjustments.

Examples of 3D scanners for the human body (Fig. 1): *Artec Eva, EinScan Pro HD (Shining 3D), Health Care Partner 3D Scanner, Revopoint POP 2., Structure Sensor 3.*

Advantages of using ***3D scanning*** (Barrios-Muriel, J. et al., 2020; Farhan, M. et al., 2021; Oud, T. et al., 2021; Silva, R. et al., 2024; https://techmed3d.com/blog/the-benefits-of-3d-scanning-in-orthotics-clinics/) include:

- *Precision and accuracy:* modern 3D scanning devices allow the capture of the patient`s anatomical details, allowing accurate digital models to be generated, thus providing a solid basis for orthosis design;
- *Patient comfort:* 3D scanning is a non-invasive and fast process, eliminating the discomfort encountered in traditional methods of making casts;

- *Efficiency:* using 3D scanning, the process of making custom orthoses is faster, shortening the time required for assessment and measurements, making it possible to process data and manufacture the orthoses on the same day;
- *Information storage:* anatomical models, obtained through 3D scanning, are saved digitally, allowing subsequent modifications of the orthosis or restoration of the orthosis, without the need to scan the patient again;
- *Reduction of errors and wasted materials:* by using 3D scanning, errors encountered when using traditional techniques are minimized; for example, in the case of using the traditional method, deformations of physical molds may occur, and through the 3D scanning method such an error can be avoided. By obtaining an accurate digital model from scanning, material waste and associated costs are reduced.

Artec Eva [20] | EinScan Pro HD [26]

Health Care Partner 3D Scanner [21] | Revopoint POP 2 [24]

Structure Sensor 3 [15]

Fig.1. 3D scanners that can be used to scan the human body

3D Design (digital design) of the orthosis is essential for processing the data collected through the scan, using this data to create the orthosis design ready for 3D printing or for milling.

Examples of digital design software: *Fusion 360*, *Rhinoceros 3D (Rhino)*, *Geomagic Freeform*, *Meshmixer*, *Blender*.

Advantages of using ***3D design*** (Li, J., & Tanaka, H., 2018; https://leopoly.com/leoshape/2024/08/12/the-transformative-power-of-cad-and-3d-printing-in-ankle-foot-orthosis-afo-design/) include:

- *Orthosis customization:* the digital design is made according to the patient`s morphology, ensuring a perfect fit;
- *Adding other elements:* support areas, cutouts or ventilation spaces can be included in the orthosis design;
- *Simulations:* advanced digital design programs allow the simulation of device use, identifying pressure points or other problems that can be corrected before manufacturing;
- *Improved accessibility and collaboration:* visualizing the orthosis design before manufacturing, through electronic sharing between specialists (doctor, technician, designer), but also to the patient, allows making small adjustments in the orthosis design, also achieving a good collaboration between the parties involved.

3D Printing/Milling represents the last technological step that consists of manufacturing the orthosis using a 3D printer (in the case of 3D printing) or a milling machine (in the case of milling). The technology of ***3D printing/milling*** leads to the fabrication of the orthosis, under computer control.

3D Printing *(additive manufacturing)* is particularly recommended for making orthotic devices which require complex design and maximum adaptability to the targeted anatomical region.

Milling *(subtractive manufacturing)* is used to make orthotic devices where the strength of the materials and the precision are a priority.

Sometimes, these two technological processes can be used complementary, for example, milling can be used to create the rigid base of the orthosis, and 3D printing can be used to create the flexible components of the orthosis, obtaining an orthosis that combines the best features of both technologies.

Examples of 3D printers (Fig. 2): *Formlabs Form 3B+, Formlabs Form 4B, Ultimaker S5, Stratasys J850 Digital Anatomy.*

Examples of milling machines (Fig. 3): *Roland DG DWX-52DCi, VHF Z4, Amann Girrbach Ceramill Motion 2, Rodin 4D Milling Machine – Model SX.*

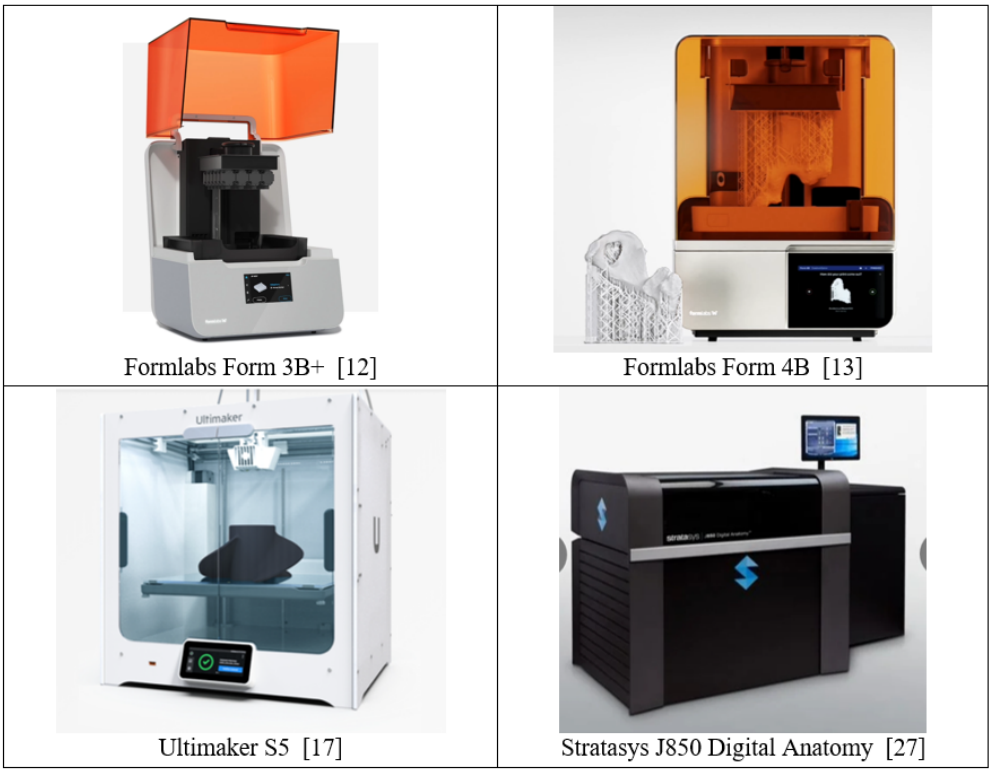

Fig. 2. 3D printers that can be used for the manufacture of medical devices

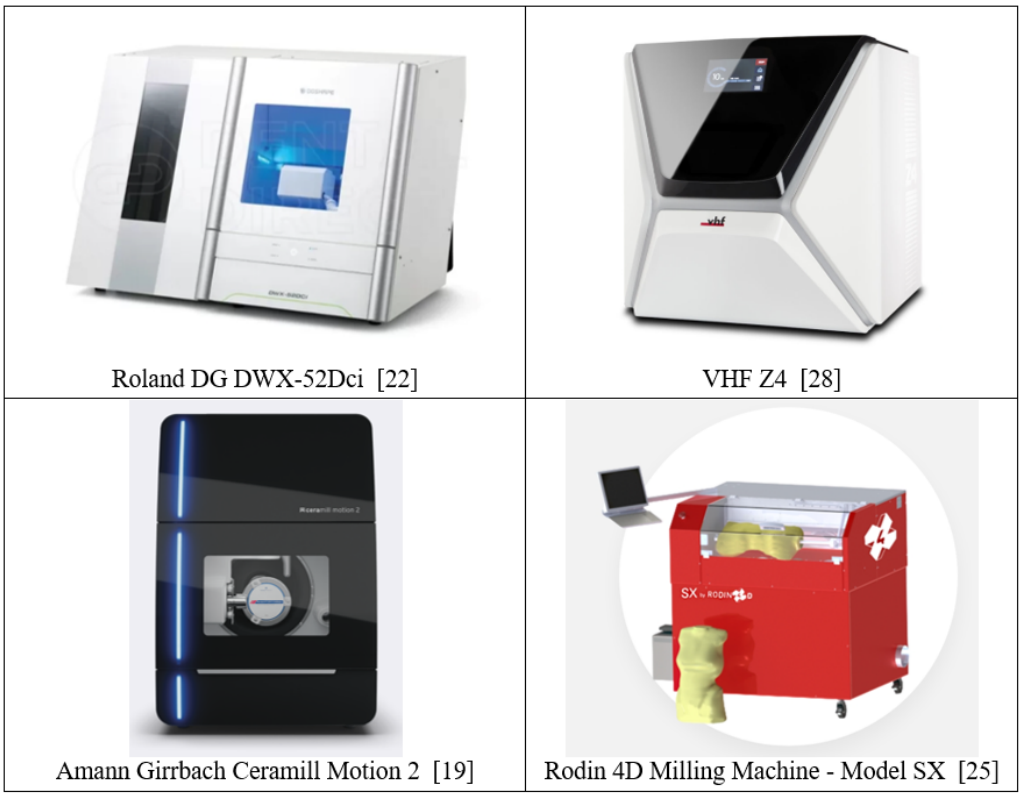

Fig. 3. Milling machines that can be used for the manufacture of medical devices

Advantages of using ***3D printing*** (Hassan Beygi, B., & Wong, M.S., 2023; Li, J. et al., 2022; Yadav, D., & Sehrawat, R., 2019) include:

- *Speed of manufacturing:* orthoses can be printed in just a few hours; this significantly accelerates delivery of the orthosis to the patient;
- *Various materials:* biocompatible materials can be used, including flexible or rigid polymers, depending on medical requirements; materials used include: PLA (Polylactic Acid), ABS (Acrylonitrile Butadiene Styrene), TPU (Thermoplastic polyurethane);
- *Weight reduction:* by using honeycomb or mesh structures, orthoses are lighter, also increasing patient comfort;
- *Precision*: using high-performance 3D printers, the orthotic device is manufactured with precision

Advantages of using ***milling*** (Anggoro, P.W. et al., 2021; https://vertexorthopedic.com/orthotic-fabrication-equipment/cnc-milling-for-precision-orthopedic-insoles-crafting-support-withunmatched-accuracy/; https://www.futurefeet.eu/wp-content/uploads/2021/10/3.FO-manufacturing.pdf) include:

- *High precision:* milling offers a very small dimensional tolerance, milling being used to obtain complex shapes and precise details, ensuring a perfect fit for the patient;
- *Durability and resistance:* the materials used in milling (metals, polyethylene sheets or dense foam) are solid and resistant, providing durability to orthotic devices;
- *Very good finish:* the surface obtained after milling is smooth and does not require major processing interventions.

Examples of using digital technology in making custom orthoses

➢ In Fig. 4, aspects of the digital technological process of making an orthosis for a patient with a chronic hand condition are presented, the patient being part of a group of 10 persons with chronic hand and wrist impairments. Patients wore both a conventionally made orthosis and a digitally made orthosis for one week each. The digital technological process consisted of several stages.

Scanning of the hand and forearm was performed with a white light scanner, *Health Care Partner 3D Scanner* (Creaform Inc., Quebec, Canada) (Fig. 4.A), using *Rodin Software 4D* (Rodin 4D, Merignac, France). The digital design (3D design) of the orthosis was made using *Fusion 360* (Fig 4.B). The orthosis was manufactured by printing with a 3D printer, *HP Jet Fusion 4200* (Hulotech, Stadskanal, The Netherlands), using *nylon "PA 12"* as material (Fig. 4.C). Advantages of using digital technology: compared to the conventionally made orthosis, the 3D printed orthosis required a shorter manufacturing time, and the 3D scanning was more comfortable than casting from the conventional method. (Oud, T. et al., 2021)

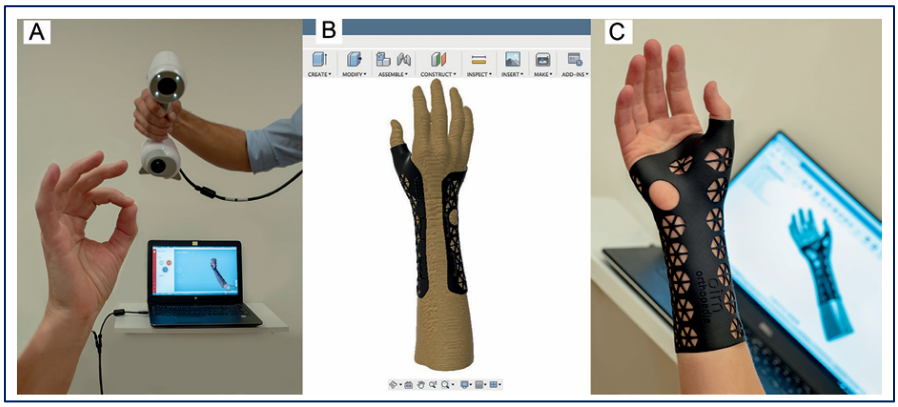

Fig. 4. The technological process for making a custom orthosis:
A. Scanning of the hand and forearm; B. Digital design of the orthosis based on the scanned model; C. 3D printed orthosis (Oud, T. et al., 2021)

➢ In Fig. 5, aspects of the digital technological process are presented for a patient with bilateral flexible flatfoot. The digital technological process consisted of several stages. A foam impression box was used for each foot (Fig. 5.a), the boxes were placed on a flat surface with reflective markers to calibrate the 3D scanner, HandyScan3D, *Proto3000Inc*. (Vaughan, ON, Canada). The patient was in a sitting position, and the patient`s feet were held in a neutral position of the subtalar joint while they were pushed into standard foam impression boxes by the orthotist. The plantar impression were scanned (Fig. 5.b). Then, the scanned data of both feet were preprocessed in the reverse engineering software, *Rapidform XOR* (INUS Technology Ltd., Seul, Coreea). After that, the processed data were input to the digital design software, *isoleCAD* (Nmotion Orthotic Lab, Knoxville, TN, SUA), for making the design of orthoses (Fig. 5.c). The orthotic insoles were printed using the 3D printer, *iSun3D Flx2* (eSUN Industrial Co, Ltd., Shenzhen, China) (Fig 5.d), and the printing material was *TPU* (Thermoplastic polyurethane). (Cheng, K.W. et al., 2021)

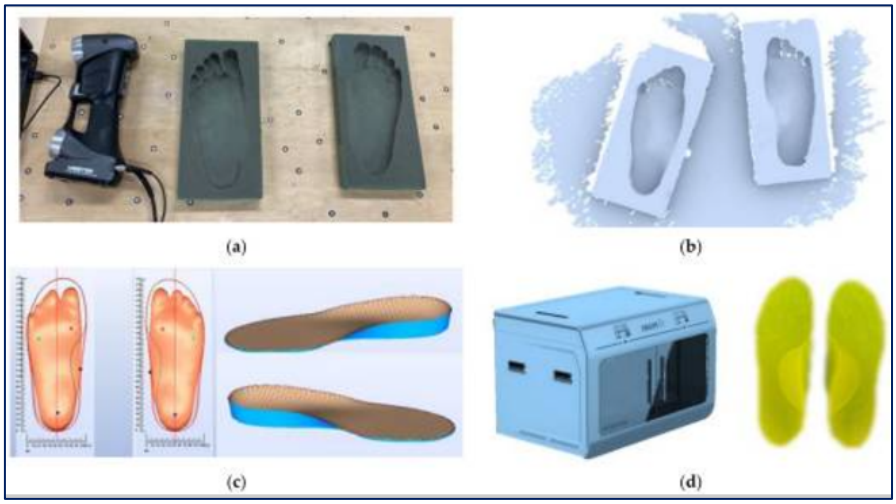

Fig. 5. Workflow for making customized orthotic insoles:
a. acquiring the shapes of the feet by stepping on the foam boxes;

b. raw data of the feet shapes digitized from the foam boxes by the 3D scanner;
c. generating the orthoses design based on the feet shapes;
d. manufacturing the 3D printed insoles (Cheng, K.W. et al., 2021)

Conclusions

The use of digital technology in the creation of custom orthoses represents an evolution in the medical field. This process ensures a high level of personalization, efficiency and comfort, also contributing to the patient`s quality of life. The integration of orthosis manufacturing technology through 3D printing or milling into the digital workflow, which also includes 3D scanning and 3D design, will lead to the creation of well-made, comfortable, affordable, fast and high-quality finished product.

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CONTRAINDICATIONS OF AQUA FITNESS

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Abstract.

The positive effects of aquatic fitness on the physical and mental health of humans are well known. Aquatic environment offers the opportunity for all individuals to practice, regardless of physical training, age, level of aquatics skills or stage in different conditions. The knowledge of aquatic exercise it is suitable for all persons, under certain safety criteria and state of the practitioner. Aquatic therapy and rehabilitation are considered multi-disciplinary specialties accredited with technical certifications. Therefore, depending on the status of each person it is advisable to ask the doctor before engaging in an aquatic fitness program. Each combination of exercises should include methodical indications about movements that has to be avoided or limited to remove application in vulnerable areas. Therefore, it should also be known if there are contraindications for aquatic fitness activities, for certain categories of people and in what circumstances this activity is not recommended.

Key words: aquatic fitness, contraindications, body maintenance.

Introduction

Aquatic activity is appropriate for all persons, regardless of age, aquatic skills learned, physical capabilities.

Aquatic aerobics practiced properly and organized offers fitness development, fun and safety in practice and is suitable for people of all ages and physical capabilities. The popularity of aquatic exercising soared. In part, because he realized that is a refreshing alternative to traditional exercise programs on land.

Aquatic aerobic fitness contributes to overall development by providing increased resistance (water) and the lack of any impact on the participants. This relatively new activity has become an ideal alternative to traditional land-based programs that are contraindicated for people with musculoskeletal problems.

Due to the specific environment, aquatic programs offer huge advantages on traditional forms of fitness activities. The exercise program can be individualized and adapted to match all the needs and possibilities of each. Water resistance causes well -trained beginners and athletes. Moreover, water offers a depreciation environment to reduce the risk of injury. It is an excellent alternative to practice for people with a broad spectrum of joints. Water floatability allows a flexibility of body joints, without tightening them too much, aquatic activities are very suitable for people suffering from arthritis and obesity. Water provides support for the body and reduces the risk of muscle or joint injury. These features make the aquatic practice suitable for a higher percentage of population than traditional exercises, from land.

Ideal activity, without causing injuries, aerobics aquatic develops different fitness components, without requests on joints, bones, tendons and ligaments, as in other activities such as running and aerobic dance, where the feet hit the ground. The injuries arising from overload are especially common in beginners. Patients with diseases in the joints or arthritis, elderly or obese people should change or eliminate activities that involve excessive jumps or trepidations. They limit the types of fitness activities available to them.

Water offers an environment that reduces trepidations. It is 1000 times dense than air and, therefore, makes most floating objects. Due to this float, the human body weighs much less in the water, creating a depreciation effect, which puts less tension on the body.

Muscle resistance is accentuated to a greater extent by aerobic aquatic practice than in most fitness activities performed on land. The higher water density offers a higher load for active muscle groups, which better stimulate muscle development and increases energy intake.

In the aquatic exercise, both the lower and upper extremities are involved, therefore, the total thing of the body is achieved. Compared to activities such as running or walking, which improve the condition of the upper extremities very little.

Aquatic exercises offer a more comfortable practice climate than it offers it on land. Practicing the muscles produces heat (caloric energy) as a by -product of energy of metabolism which, alternatively increases body temperature. Many people, especially obese, do not tolerate heat and therefore are not able to practice in high temperatures. The heat can be spent much more efficiently in water than on land. Therefore, aquatic practice significantly reduces the tension caused by heat and makes practicing more comfortable and tonic. The stroke caused by heat and exhaustion due to heat is removed in the water (except where the water temperature is too high).

Like any exercise program or treatment environment, there are both advantages and disadvantages in choosing aquatic exercises. For the people for whom the aquatic program is completed represent an option available for a condition, the advantages are profound.

Reflecting the theme in the literature

Today, aquatic therapy and rehabilitation specialists consider a multidisciplinary professional with credentials offered by specialized committees.

For pregnant women J. Katz (1995) considers „an ideal aerobic aquatic activity", „enjoying the refreshing feeling of water while exercising" felt especially when the pregnancy advances, however, „avoiding any movement or process that feels uncomfortable" and taking care that the movements to be line because the ligaments are soft during pregnancy and postpartum".

„Aquatic safety is always a priority, especially in water, where minor accidents can have serious consequences" (Katz J., 2003).

It is recommended that before entering the water to check the safety equipment with will work, water clarity, safety precautions, including water temperature, texture of the pool floor (in small pools).

All patients should have a comprehensive assessment, part of which will assess the suitability of the patient for this intervention and will include screening for contraindications and precautions. (Cross, A. J. et all, 2020)

Issues addressed

Aquatic therapy and rehabilitation are considered multi-disciplinary specialties accredited with technical certifications.

Body heating before the main program is essential as recovery from the program. Breathing should be rhythmic during each exercise, without holding breath. Exhalation should be complete after every effort to remove lactic acid and carbon dioxide. Compliance with these aspects facilitate strengthening the body safely, without endangering the health and integrity.

Medical Conditions

Before starting any exercise program is recommended to consult a doctor. This is particularly relevant for people with a history of cardiovascular problems, lung disease, muscular and bone disease or hypertension. Other possible contraindications include open wounds, chlorine allergy, skin infections or contagious conditions and fever.

People with special needs

Water aerobic exercise is an appropriate way for most healthy individuals. Certain groups of people, however, may need to adapt the exercises to their specific conditions. These special groups include pregnant or after childbirth, children, obese people and elderly. Special programs can be designed for these people or can be integrated into regular programs for aquatic fitness.

Pregnant women

This group of people including pregnant women and those in the first 6 weeks after birth or who are breastfeeding. They should:

- work in a comfort zone,
- use perceived effort to determine the optimal intensity pace,
- avoid overheating,
- avoid prolonged exposure to sunlight, if aquatic activities take place outdoors, because of excess pigmentation that can lead to „mask of pregnancy", called melasma, which has the effect of pigmentation of the upper lip, cheeks or forehead,
- drink plenty of water before, during and after exercise,
- do not force joints,
- avoid swimming in butterfly stroke because it is a process demanding, causing arching the back too much (fins can make up in the third quarter),
- diving, pushing strong in the wall should be postponed after birth because the pressure forces the uterus and upon the fetus,
- avoid any exercise that would endanger health and safety over the baby.

Children

This group can be divided into categories according to age and development of motor skills, but mainly, children will have fun. They should:

- work safely,
- use perceived effort to determine the optimal intensity pace,
- consume enough water,
- work with interval training and / or circuit, often changing the exercises, so as not to get bored,
- be included varying levels of difficulty,
- be given positive feedback, permanently.

Obese people

For many overweight people is the only environment where water can practice. They must:

- work in a comfort zone,
- use perceived effort to determine the optimal intensity pace,
- drink plenty of water before, during and after exercise,
- alternate exercises in shallow with deep water,
- perform full range of motion exercises,
- perform simple exercises.

Older people

These people can take full advantage of aquatic exercise. To ensure the safety and effectiveness of practicing, they must:

- work in a comfort zone,
- use perceived effort to determine the optimal intensity pace,
- drink plenty of water before, during and after exercise,
- develop the force through aquatic movements,
- include mobility exercises,
- maintain a simple exercise program,
- make from aquatic training also a way of socializing.

Although it is unlikely that someone drown during aquatic fitness activities, there are people who fear into deep water, where they can not reach the bottom of the pool. This situation may be limited to exercising in water depth between the waist and ribs (to protect the lumbar spine), near the edge of the pool. Over time, the familiar, most people lose confidence and fear of water.

Low blood pressure is not necessarily a contraindication for aquatic aerobics, but too much practice in water can exacerbate the situation. It is not working completely empty stomach, and dizziness or nausea if it occurs, stop the program. Check that air and / or water temperatures are higher than usual and practice with a certain intensity.

It is important that a person with epilepsy to be accompanied by someone who knows the situation and intervene in a crisis.

Aquatic aerobics is safe for almost everyone, with few exceptions. The most important thing is to adapt training to the needs and obictivele each.

Contraindicated exercises

These are exercises that can harm to the body when performed repeatedly. Often, there are exercises familiar to many „everybody makes them". In the past, there were no means of research and study pressure that require muscles, joints, tendons and ligaments when practicing. Now that scientists can confirm the risk involved. Must know which exercises are best avoided or can be modified to take advantage without risk of disease.

There are a number of movements to be avoided because of risk of injury or excessive application: **high-impact continuous movement**, in which the body is lifted from the water after the jump. This is true in shallow water and the sea. People work in water to prevent any strain which comes from gravity and high-impact forces. Can be achieved exercises in water with high intensity without high impact.

Fast movements or movements to the tempo of the land. Exercises in water requires slow movements to overcome water resistance and maintain the appropriate alignment. To perform the exercises safely, the tempo from the land should be reduced the area of movement, which reduces work efficiency.

Use the arms overhead continuously to stimulate vascular response. It occurs when, to push the blood against gravity to the arms and head, the heart has to beat harder and faster. Continuous movement of the arms above the head can also produce problems in the shoulder joint.

Arm movement in and out of the water while exercising can cause accidents at shoulder joint because of the surface tension.

Arms in the water and out of the water

Because of the hydrodynamic principle can develop greater strength through practice with hands in water and not outside them. Opinions differ about the practice of arms out of the water. When arms are out of the water your heart rate is artificially higher, which does not give a true intensity of exercise. In addition, lack of control of the arm can cause tension and lead to possible injury of the back.

Arm exercises out of the water must be limited. Gentle, controlled out of the water for the development of range of motion in joints, should be used during the heating phase and / or recovery. During the aerobic phase exercises with the arms out of the water that can be used are those in which movement takes place outside the water and in the water when hands are close to the trunk.

In addition, these exercises should be limited for short periods of time and be combined with a powerful kicking. Because it will continue to maintain optimal heart rate zone training and will allow shoulder muscle training throughout their range of motion. Furthermore, intermittent movements of arms out of the water can provide variation in preparation. If there is discomfort in the arm position should be changed drill by lowering or eliminating arms complete from the action.

The water temperature

Water temperature is most comfortable between 26 and 28^0 C. If the temperature is lower heating exercises should be done over a longer time and reduce mobility exercises as aerobic phase that occurs at the end of the lesson. High water temperatures between 29.5 and 31^0 C can be risky. Muscles produce heat during exercise. If water temperature is too high, the combination of warm

water can lead to increased body heat exhaustion or heat stroke induced. Untreated, this can be fatal stroke.

Conclusions

Although there are many contraindications to aquatic fitness there are still some conditions where more attention is required.

One aspect to consider in aquatic fitness is the ability find out the shape of the organism to perform in that moment of the day as it was then organismul se of, without strain.

If the sensation of pain occurs, stop breathing, dizziness occurs must stop the program and leave the pool to rest.

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RUPTURE DU LIGAMENT CROISÉ ANTÉRIEUR CHEZ LES JEUNES FOOTBALLEURS

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Abstract
L'être humain, de par ses particularités biomécaniques, et je pense notamment à celles résultant de l'adoption d'une démarche bipède, est donc sujet à différents types de lésions spécifiques à cette position, et l'articulation du genou est l'une des plus exposées. La reconstruction chirurgicale du ligament croisé antérieur est actuellement l'une des interventions orthopédiques les plus courantes. Ces dernières années, les patients souffrant de ce type de blessure semblent être de plus en plus souvent orientés vers la chirurgie reconstructive. Cette affirmation est basée sur les rapports du National Endoprosthetic Registry, qui indique un nombre de 759 cas en 2015 et 970 reconstructions ligamentaires en 2016. Cette tendance à la hausse se poursuit au cours des deux prochaines années, lorsque le nombre de ligamentoplasties dépassera les 2000 cas en 2018. En raison du coût élevé qu'entraîne une intervention chirurgicale de ce type, de la longue convalescence nécessaire pour les patients mais aussi des conséquences qui en découlent *(sociales, psychologiques)*, cette tendance à la hausse, comme prévu, n'est pas passée inaperçue. La même tendance à la hausse peut être observée au niveau international, comme je l'expliquerai plus loin. Dans ces conditions, l'intérêt porté à ce sujet par un grand nombre d'articles et d'études spécialisées n'est pas surprenant. Pour résumer cette problématique, je constate que l'attention des spécialistes du domaine s'est portée dans plusieurs directions.

Introduction

En général, l'articulation du genou est sollicitée de manière égale lors des activités physiques, mais elle est également exposée à différents types de traumatismes. En particulier, la rupture du ligament croisé antérieur a des conséquences graves en raison de la nécessité d'une intervention chirurgicale coûteuse, d'une longue période de récupération et de la probabilité d'une apparition prématurée de l'arthrose.

Ce sont là quelques-unes des raisons qui, selon moi, justifient l'intérêt porté à ce type de blessure au niveau international au cours des dernières décennies. La plupart des études scientifiques se sont concentrées sur les causes des lésions du ligament croisé antérieur *(LCA),* notamment en ce qui concerne le mécanisme de production, les méthodes d'entraînement qui réduisent la probabilité de blessure et les techniques de récupération qui accélèrent la guérison postopératoire. Par exemple, un certain nombre d'articles scientifiques ont été publiés dans des revues prestigieuses, indiquant un facteur de risque d'environ 30 % plus élevé chez les femmes dans la même discipline sportive.

L'inquiétude des scientifiques est compréhensible au vu de l'augmentation alarmante de ce type de traumatismes. Aux États-Unis, on parle depuis plusieurs années d'une véritable « épidémie », avec environ 200 000 lésions de ce type recensées chaque année, dont la moitié nécessitera une intervention chirurgicale.

A l'heure actuelle, seuls trois autres pays *(Suède, Norvège et Danemark)* disposent d'une base de données nationale où sont enregistrées les lésions du ligament croisé antérieur. Dans le cas de la Norvège, cette initiative remonte à 2004 et les deux autres pays n'ont adopté la même mesure qu'un an plus tard, en 2005. Il faut préciser que le Danemark est le seul pays où la déclaration à la base de données est obligatoire. Ces sources nous apprennent que 34 cas pour 100 000 habitants sont enregistrés chaque année en Norvège, 38 cas/100 000 habitants au Danemark et 32/100 000 en Suède.

Dans certains cas, les données publiées par les compagnies d'assurance ont été utilisées. Par exemple, en Allemagne, elles estiment à 32 le nombre de cas pour 100 000 habitants et en

Nouvelle-Zélande à 37 le nombre d'accidents signalés pour 100 000 habitants. Ces données ont été recueillies entre 1990 et 1995 en Allemagne et entre 2000 et 2005 en Nouvelle-Zélande. D'une manière générale, sur base de toutes ces données, mais aussi d'autres données similaires publiées dans plusieurs pays *(Italie, Canada et Etats-Unis),* on peut estimer une incidence entre 30-37 cas pour 100.000 habitants, ce qui est très proche de ce qui a été publié dans les pays scandinaves, avec seulement une légère variation par pays sur une période de temps similaire.

Il convient de noter que ces chiffres représentent l'ensemble de la population des pays en question, mais lorsque l'on s'intéresse aux athlètes de haut niveau, on constate des variations significatives en fonction de la discipline sportive pratiquée. Cela est évident même si l'on utilise des méthodes différentes pour la communication des données. Certaines études font état du nombre d'athlètes blessés au cours d'une période donnée, tandis que d'autres prennent en compte le nombre de participants et d'heures d'exposition à l'activité en question, lorsqu'ils sont considérés comme plus susceptibles de se blesser.

Cela nous rappelle une étude menée par la National Collegiate Athletic Association (NCAA) aux États-Unis, qui fait état de 14 blessures pour 100 000 heures d'exposition chez les joueurs de football entre 1989 et 2005. Une étude similaire menée en Italie sur des joueurs de football semi-professionnels entre 1993 et 1996 fait état d'une incidence de 7,7 cas pour 100 000 heures. Dans le même temps, une étude rétrospective portant sur des footballeurs français ayant joué au niveau régional et national entre 1991 et 2003 a révélé une incidence de rupture du ligament croisé antérieur de 1,58 %.

Des différences significatives peuvent être observées lorsque les données d'autres sports sont analysées et comparées, par exemple le ski alpin, avec une incidence de 50 pour 100 000 skieurs par jour, selon une étude menée aux États-Unis. Ce même pays signale également 17 blessures pour 100 000 heures chez les joueurs de basket-ball.

La conclusion à laquelle nous parvenons est que, quelle que soit la manière dont ces valeurs sont rapportées, il semble y avoir de petites variations lorsque l'on compare la population de différents pays. En même temps, nous trouvons des différences significatives lorsque nous considérons certaines disciplines sportives dans différents pays ou régions. Cela suggère que les facteurs génétiques ou environnementaux ne jouent pas le rôle le plus important, bien qu'ils ne doivent pas non plus être exclus, mais nous attribuons ces différences à la méthodologie d'entraînement qui diffère d'un pays à l'autre. Cela souligne que les entraîneurs, les médecins du sport et les décideurs n'ont pas accordé la même attention à la prévention de ce type d'accident. Le développement de protocoles de test et de méthodologies d'entraînement ciblées pour prévenir les déchirures ligamentaires semble extrêmement utile.

L'une des méthodes d'entraînement utilisées avec des résultats prometteurs en Italie est l'entraînement proprioceptif. Une étude réalisée en Italie montre une incidence réduite de 30 % pour les athlètes qui ont suivi ce type d'entraînement pendant seulement 20 minutes par jour, par rapport au groupe de contrôle qui a continué à s'entraîner par des moyens traditionnels. Des résultats similaires ont été obtenus au Japon, où l'on a étudié des équipes de judo, et en Australie, où l'on a mis en place ce type d'entraînement pour les joueurs de rugby.

À l'appui de cette idée, des études récentes indiquent que le dysfonctionnement neuro-musculaire est le principal facteur prédictif des déchirures ligamentaires. En conséquence, des méthodes d'entraînement neuro-musculaire spécifiques (HarmoKnee) ont été mises en œuvre avec succès en Suède pour les joueurs de football, et aux États-Unis, le programme Sport Metric est utilisé pour les joueurs de basket-ball et de volley-ball.

De nombreuses études ont analysé les causes et les mécanismes des déchirures ligamentaires, mais il convient de noter que celles qui n'impliquent pas de contact avec un autre athlète sont appelées déchirures sans contact. Par conséquent, des méthodes de prévention ont été développées, en particulier chez les femmes, dont on sait qu'elles sont environ 30 % plus exposées à ce type de traumatisme.

Au cours des dernières décennies, les progrès technologiques et une approche interdisciplinaire du problème, ainsi qu'une meilleure compréhension des facteurs favorisants, ont permis de réduire considérablement le temps de récupération des patients. Je fais ici référence en particulier à l'implication du système nerveux et au rôle accru attribué à la proprioception tant dans la prévention que dans le traitement.

Critères physiques/fonctionnels

Il n'y a actuellement pas de consensus sur les critères qui déterminent le mieux l'aptitude physique et fonctionnelle d'un athlète à la RTS. Barber-Westin et Noyes16 ont réalisé une revue systématique de 264 études évaluant la RTS et ont constaté que 40 % des études incluses ne fournissaient aucun critère, 32 % fournissaient comme seul critère le temps postopératoire, 15 % détaillaient le temps et les critères subjectifs et 13 % se concentraient uniquement sur les critères objectifs. En outre, les opinions cliniques des membres de l'American Academy of Orthopaedic Surgeons (AAOS) concernant les critères de RTS restent très variables.17,18 Dans une revue des protocoles de rééducation post-ACLR de 42 programmes orthopédiques universitaires américains, Makhni et al19 ont constaté un manque frappant de con sensus. Seuls 19 % d'entre eux recommandaient d'atteindre certains critères de force et d'activité avant la RTS, et il n'y avait pas de cohérence dans les tests recommandés utilisés ou le délai recommandé pour la RTS.

Plusieurs batteries de tests ont été mises au point pour évaluer la fonction physique et la récupération du genou d'un athlète après un ACLR. En général, elles comprennent une combinaison des évaluations quantitatives suivantes : divers tests de saut, des tests de saut/atterrissage, des tests de force utilisant la dynamométrie isocinétique ou isométrique, et/ou l'arthrométrie ligamentaire KT-1000.

Les tests de saut sur une jambe et les tests de force isocinétique du quadriceps sont les plus couramment utilisés. Le Limb Symmetry Index (LSI) est souvent utilisé comme principale mesure de résultat pour ces tests. Cependant, il est de plus en plus évident que la jambe controlatérale peut s'affaiblir après un ACLR suite à un déconditionnement ou qu'elle était peut-être déjà faible au départ, ce qui implique que l'indice de symétrie des membres a une valeur discutable pour éclairer les décisions de RTS. En outre, les chercheurs ont suggéré que les scores optimaux pour les tests isocinétiques de force et de saut devraient être ≥ 90 % sur l'INS, mais de nombreuses études n'exigent que 80 à 90 %. Outre le large éventail de critères quantitatifs pour les RTS, le taux auquel les athlètes satisfont à ces critères est également très variable.

Les études qui utilisent diverses combinaisons de tests de saut, de tests de force isocinétique, de sauts verticaux et de résultats rapportés par les patients ont rapporté que le pourcentage de patients avec des critères de réussite se situait entre 0 et 7 % à 6 mois. Une méta-analyse récente a révélé que la proportion d'athlètes satisfaisant aux critères de la RTS allait de 23 % à 73 %.20 Bien que ces tests soient généralement un élément clé des critères actuels de la RTS, il n'existe aucune preuve de leur capacité à modifier le risque de seconde lésion du LCA ou à prédire une future lésion du genou. La même méta-analyse n'a trouvé aucune association entre la réussite des critères objectifs de la RTS et la diminution du risque de seconde lésion du LCA.

Les protocoles conventionnels d'évaluation et de rééducation manquent donc de sensibilité et de spécificité et peuvent donner un faux sentiment de préparation sans mettre en évidence les facteurs de risque cliniquement pertinents d'une seconde blessure. Jusqu'à présent, les critères de la RTS n'ont pas intégré de manière cohérente et systématique des informations sur la qualité du mouvement, qui est la caractéristique des programmes de prévention des lésions du LCA. Comme la grande majorité des lésions du LCA dans les sports à haut risque sont sans contact, les principes de la prévention primaire des blessures s'appliquent également à la rééducation post-ACLR, puisque nous essayons de prévenir une seconde blessure.

À cette fin, une évaluation de la qualité du mouvement (QMA) a été mise au point pour identifier les déficits physiques qui contribuent aux facteurs de risque conduisant à des schémas de mouvement défectueux et pour fournir des recommandations ciblées en vue d'une RTS sûre. L'évaluation de la qualité du mouvement a été mise au point à la suite d'observations répétées de schémas de mouvement défectueux lors de la sélection d'athlètes ayant reçu l'autorisation médicale de pratiquer la RTS. La combinaison de résultats satisfaisants aux tests quantitatifs et à l'AMQ a permis de prendre des décisions opportunes en matière de RTS et de réduire le risque de nouvelles blessures. Sur les 42 athlètes évalués, 83% ont été autorisés à reprendre une activité sans restriction et 14% ont subi une seconde blessure, dont trois dans des sports pour lesquels l'athlète n'était pas autorisé.

Le QMA est enregistré sur vidéo puis revu avec l'athlète pour l'informer de la présence de schémas de mouvement à risque et lui donner des recommandations ciblées pour guider les prochaines étapes du processus de rééducation. Le QMA se compose de deux sessions : Le QMA 1 a lieu 6 mois après la rupture du ligament croisé antérieur et le QMA 2 a lieu 8 semaines après la première séance. Lorsque l'athlète revient pour la QMA 2, tous les mouvements de la QMA 1 sont d'abord exécutés, puis on passe à des mouvements plus exigeants et de plus haut niveau (saut en largeur, saut à l'opposé, saut sur une jambe, décélération, coupe aléatoire et coupe à 90 degrés). Cette progression permet au physiothérapeute/spécialiste certifié de la force et du conditionnement de noter et de renforcer les progrès réalisés grâce aux recommandations formulées lors de la QMA 1.

Critères psychologiques

Les taux sous-optimaux de RTS après ACLR ont suscité une enquête sur l'inadéquation des évaluations fonctionnelles ainsi que sur d'autres facteurs susceptibles d'influencer la RTS. Des réactions psychologiques spécifiques à la blessure initiale, à la chirurgie et à la rééducation ont été associées à la réussite ou à l'échec de la RTS. Ces réactions psychologiques comprennent l'estime de soi, la confiance, la motivation et l'optimisme. Les patients qui ont des réactions psychologiques positives sont plus susceptibles d'obtenir de meilleurs résultats en matière de réadaptation, car le fait d'avoir moins de peur et d'anxiété est positivement corrélé à la RTS.10,31-34 L'inverse peut également être vrai : les patients dont la réadaptation est plus complète et qui sont prêts à revenir ont plus de chances d'avoir de meilleures réactions psychologiques.

Ainsi, toute appréhension ressentie par l'athlète quant à son état de préparation à la RTS peut indiquer que la rééducation est incomplète. Afin d'opérationnaliser les facteurs psychologiques liés à la reprise du sport, Webster et al35 ont mis au point une échelle permettant de quantifier l'état de préparation psychologique d'un athlète qui reprend le sport après une rupture du ligament croisé antérieur (ACL). L'échelle ACL-RSI (Anterior Cruciate Ligament Return to Sport after Injury) est un questionnaire validé de 12 questions qui mesure les émotions de l'athlète, sa confiance en ses performances et en la fonction de son genou, ainsi que l'évaluation du risque de blessure future, un score plus élevé indiquant une plus grande confiance et une moindre peur de se blesser à nouveau. L'échelle a permis de prédire les résultats de la RTS: Les scores de l'ACLRSI ont augmenté au cours de la rééducation et 6 mois après l'ACLR, et les athlètes qui ont repris le sport ont obtenu des scores significativement plus élevés que ceux qui ne l'ont pas fait. Un éditorial récent a souligné que les mesures physiques/fonctionnelles ne représentent qu'un tiers de la variance des scores ACL-RSI.

Cette constatation indique que la préparation psychologique est largement distincte des normes traditionnelles utilisées pour déterminer la préparation à la RTS et qu'elle devrait faire partie d'une évaluation complète. On ne sait toujours pas si la préparation physique et la préparation psychologique sont indépendantes l'une de l'autre ou si l'une est directement influencée par l'autre. Dans un cas comme dans l'autre, la méthodologie conventionnelle est insuffisante pour interpréter l'état de préparation à la RTS. Les protocoles de rééducation actuels, basés sur des mesures arbitraires telles que l'INS, peuvent créer une fausse perception de l'état de récupération. Les

athlètes sont induits en erreur par la réussite de tests quantitatifs malgré une rééducation incomplète. Il est donc important de reconnaître que les processus de récupération psychologique et physique peuvent ou non se dérouler en parallèle.

À l'heure actuelle, il n'y a toujours pas de règle d'or pour autoriser les athlètes à bénéficier d'une STR après une ACLR. Les décisions sont souvent multifactorielles, ce qui peut contribuer à expliquer cette absence de consensus. Les tests qui évaluent les facteurs physiques ou psychologiques, qu'ils soient qualitatifs ou quantitatifs, n'ont pas une relation univoque avec les décisions relatives à la RTS. Ces décisions sont plutôt un exemple du « système complexe » récemment proposé par Bittencourt et al. Des approches méthodologiques plus avancées sont nécessaires pour identifier la stratégie optimale pour la prise de décision clinique.

Les objectifs de recherche futurs devraient inclure la standardisation des critères de RTS et l'identification des facteurs pronostiques qui prédisent la réussite de la RTS. La littérature sur la RTS est remplie d'évaluations de tests menées de manière isolée plutôt que de mesurer leur contribution à l'algorithme de décision. Au lieu de se fier à un seul test, les résultats de tests multiples et les caractéristiques individuelles qui exposent un athlète à un risque de blessure représenteront mieux l'ensemble du tableau clinique. Pour quantifier la combinaison de facteurs physiques, psychologiques et liés au patient qui contribue le plus aux décisions de RTS, un modèle de prédiction multivariable peut estimer la probabilité de retour sur la base du profil individuel d'un athlète.

L'utilisation d'une règle de prédiction clinique peut être en mesure d'apporter une structure quantifiable pour surmonter l'influence des considérations arbitraires qui interviennent dans les décisions de RTS. Une partie de toutes les approches de mesure (tests quantitatifs, tests qualitatifs tels que ceux de l'AMQ, et résultats rapportés par le patient tels que l'ACL-RSI) peut permettre de mieux prédire les RTS. Une validation plus poussée d'un modèle pronostique peut servir d'aide à la décision pour s'assurer que les athlètes qui reviennent d'une blessure au LCA sont physiquement et psychologiquement prêts à retourner sur le terrain.

La méthodologie actuelle des tests RTS consiste en des outils quantitatifs qui sont des mesures de performance. En revanche, une rééducation sûre basée sur l'identification et la modification des schémas de mouvement qui ont mis l'athlète en danger sera plus efficace pour réduire les blessures ultérieures. Le QMA est basé sur la pyramide des performances proposée par Cook et al, selon laquelle la compétence gestuelle constitue la base de la performance et de l'habileté sportives. L'AMQ peut aider les athlètes à atteindre leur objectif de RTS en leur permettant de comprendre les facteurs de risque qui ont contribué à leur blessure. L'AMQ met également en évidence les points à améliorer sur le chemin de la guérison et apporte une clarté visuelle lors de l'examen vidéo des schémas de mouvement à haut risque.

Conclusions

Rétrospectivement, en considérant à la fois l'expérience pratique acquise au cours des 12 derniers mois en participant à l'élaboration du protocole de récupération et à sa mise en œuvre et la période de documentation nécessaire à l'élaboration de cet article, je conclus que la sensibilité proprioceptive, bien que bien étudiée et documentée sur le plan théorique, est peu exploitée en pratique.

La présente étude s'est concentrée sur la rééducation de l'altération de la sensibilité proprioceptive suite à une ligamentoplastie. Je pense que ces techniques spécifiques contribuent de manière significative à raccourcir le processus de récupération et de réinsertion dans l'activité. Cependant, nous n'excluons pas la possibilité que certaines déficiences sensorielles ou neuro-motrices aient pu contribuer à cette blessure. Nous pouvons ici parler du rôle de la proprioception dans la prévention des blessures, qui est également un sujet d'actualité.

En d'autres termes, je pense que la mise en œuvre pratique de techniques et de méthodes de travail qui mettent l'accent sur cette fonction sont nécessaires à la fois dans les cours d'éducation

physique, l'entraînement sportif ou la pratique de la kinésithérapie, est la seule direction à suivre dans la prochaine période. Je pense qu'il est toujours nécessaire d'adopter une approche interdisciplinaire de ces questions afin de continuer à progresser en termes de santé de la population ou de performances sportives.

On sait que la sédentarité a un effet extrêmement néfaste sur les systèmes cardio-respiratoire, ostéo-articulaire et musculaire, mais on connaît moins bien son rôle dans l'altération de cette sensibilité proprioceptive, qu'il faut comprendre et combattre, ce qui incomberait notamment au professeur d'éducation physique. Lorsque cette fonction est inhibée, soit, comme je le disais, en raison d'un mode de vie sédentaire, soit en raison de blessures antérieures, elle prédispose la personne concernée à des blessures consécutives, potentiellement de plus en plus graves. C'est là qu'interviennent les entraîneurs sportifs et les physiothérapeutes, dont le rôle dans la prévention des blessures *(lorsqu'ils travaillent avec une équipe sportive)* reste à établir.

On peut s'attendre à ce que les progrès scientifiques et technologiques s'accélèrent à l'avenir, et nous assisterons certainement à l'émergence de technologies que nous avons du mal à imaginer aujourd'hui. C'est pourquoi je pense qu'une action concertée des spécialistes de notre domaine est nécessaire tant au niveau de la prévention des blessures que de la récupération.

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