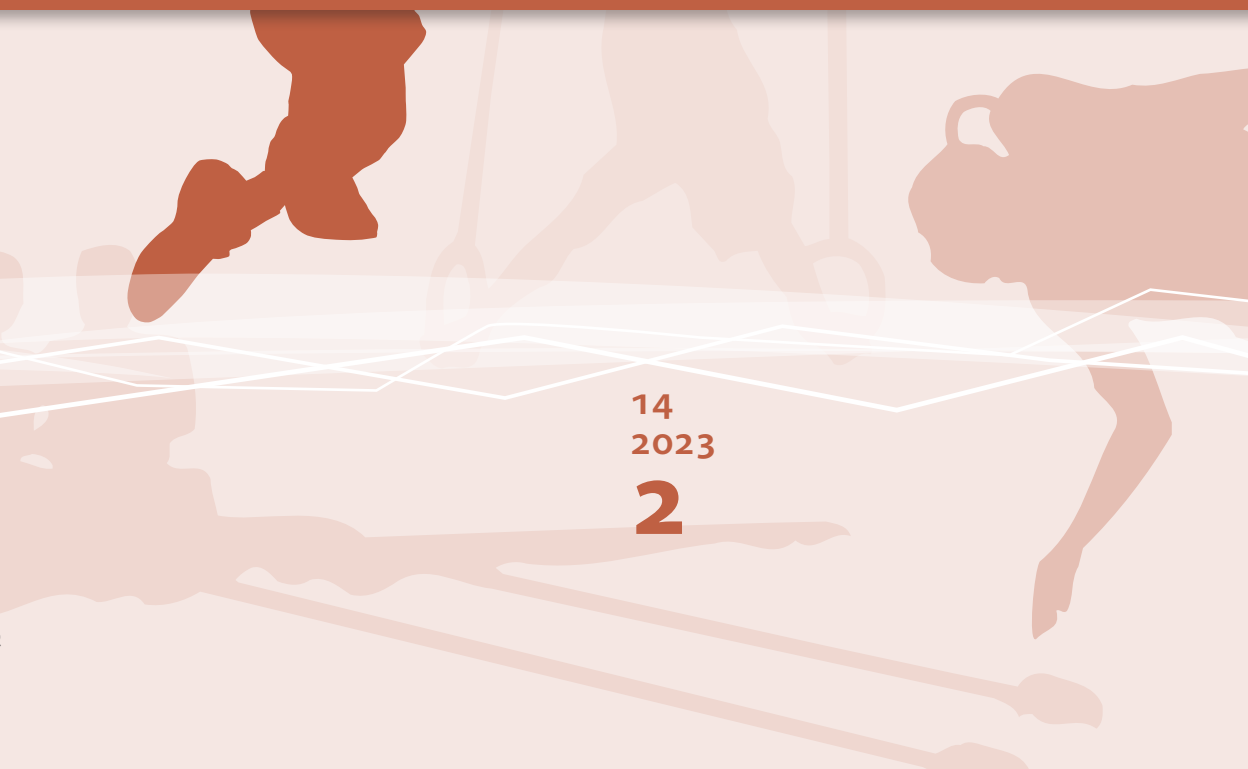
AnnalesKinesiologiae

UDK / UDC 796.01:612 | Annales Kinesiologiae 14, 2023, 2, pp. 91–188 | ISSN 2232-2620



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UDK / UDC 796.01:612 | **Annales Kinesiologiae** 14, 2023, 2, pp. 91–188 | **ISSN 2232-2620**

Koper 2023

ISSN 2232-2620 UDK/UDC 796.01:612 Volume 14, Year 2023, Number 2
ISSN (online ed.) 2335-4240

Publisher ***/ Izdajatelj:*** Science and Research Centre Koper, Annales ZRS / Znanstveno-raziskovalno središče Koper, Annales ZRS

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Home page: http://ojs.zrs-kp.si/index.php/AK

Printing / ***Tisk:*** Grafika 3000 d.o.o.

Quantity ***/ Naklada:*** 250 copies per issue

Financial support ***/ Finančna podpora:*** *The publishing of this journal is supported by the Foundation for Financing Sport Organisations in the Republic of Slovenia and the Slovenian Research Agency.*

Fundacija za šport
www.fundacijazasport.org

Slovenian Research and Innovation Agency

Izdajo revije sofinancirata Fundacija za financiranje športnih organizacij v Republiki Sloveniji in Javna agencija za raziskovalno dejavnost Republike Slovenije.

Journal abbreviation: Ann. Kinesiol.
Annales Kinesiologiae is an international journal published twice a year.
Annual subscriptions (2 issues in English language) are available for 25 eur, and a single issue is available for 15 eur. For students 20% discount applies upon presenting an international valid student ID.
Subscription requests can be send to: annaleskin@zrs-kp.si

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OCENE IN POROČILA

EDITORIAL

Dear readers, the second issue of volume 14 of our scientific journal Annales Kinesiologiae represents a further contribution to the understanding of the scientific background of kinesiology. At a time when the concept of open science is increasingly gaining ground in the scientific community, we are pleased to point out that the editorial policy of Annales Kinesiologiae has been on providing the so-called diamond open access to content throughout the years.

This issue of the journal, in addition to the two regular sections of original and review scientific articles and reports from conferences and other events, includes an interesting article in the "Technical notes" section.

The first review article addresses the pressing issue of Parkinson's disease and the use of an innovative virtual environment approach in patient management. The authors of the paper conclude that virtual reality as a type of augmented environment has the potential to create multiple sensory experiences and feedback that influence different aspects of information processing and patient response. The literature review aimed to identify the possible effects of VR training on balance in Parkinson's disease patients. The results suggest a need for further development of this technology, in particular a focus on immersive form of virtual reality, which in particular shows potential for improving balance in individuals with Parkinson's disease.

In the following original scientific paper, the authors assessed foot posture and hip joint flexibility in top handball and football players and investigated possible relationships between these measures. By comparing the differences in the indices between the three groups of subjects, the measurements yielded interesting results that highlight the need for further in-depth research.

The next paper, a review article, explores the beneficial effects of physical activity and sport on arterial blood pressure in older people with cardiovascular disease. Based on 15 selected studies, it was found that physical activity, regardless of the form of exercise adapted to the elderly population, has positive effects on arterial blood pressure in elderly cardiovascular patients.

Another review article explores the positive effects of different forms of exercise in the management of chronic fatigue syndrome/myalgic encephalomyelitis in the working population. The authors conclude that the selected studies consistently demonstrate positive effects on both physical functioning and fatigue reduction in working individuals with chronic fatigue syndrome.

The "Technical notes" section provides an interesting contribution to the pressing issue of overuse injuries in the young athlete population. Recently, there has been a dramatic increase in adolescent participation in sport in ways

that go beyond the basic recreational level. Unfortunately, one of the consequences of this trend is an alarming increase in overuse syndromes. This article reviews, in a transparent manner, both the identified risk factors as well as the pathophysiology and possible preventive measures in young athletes. An important focus of the article is the recommendation that more energy should be directed towards prevention. Prevention is emphasized, advocating against early specialization in sport and promote adequate rest. In order to maintain mental and physical health, the authors recommend a variety of sporting activities, limiting the number of training hours and having a system in place to help with perceived problems.

The issue of the journal concludes with reports from two conferences: the 28th Annual Congress of the European Sport Science Association, hosted by the French Institute of Sport (INSEP) in Paris from 4 to 7 July 2023, and the 12th edition of the international scientific and professional conference A Child in Motion, held in Portorož, Slovenia, from 2 to 4 October 2023, under the theme "Change the game – a modern way back to the roots".

You are cordially invited to read the entire contributions, technical notes and reports.

Matej Plevnik, PhD,
Editor

UVODNIK

Spoštovane bralke in bralci. Tudi drugi zvezek letnika 14 naše znanstvene revije Annales Kinesiologiae predstavlja nadaljnji prispevek k razumevanju kineziologije in njenega znanstvenega ozadja. V času, ko se v znanstvenem okolju vse bolj uveljavlja koncept odprte znanosti, z veseljem poudarjamo, da politika uredništva Annales Kinesiologiae vsa leta vztraja pri zagotavljanju tako imenovanega diamantnega odprtega dostopa do vsebin.

Tokratno številko revije poleg dveh rednih rubrik izvirnih in preglednih znanstvenih člankov ter poročil iz konferenc in drugih dogodkov, sestavlja še zanimiv članek v rubriki Tehnična poročila.

Prvi pregledni članek nagovarja perečo problematiko Parkinsonove bolezni in uporabo inovativnega pristopa virtualnega okolja pri obravnavi pacientov. Avtorji članka ugotavljajo, da navidezna resničnost, kot vrsta obogatenega okolja, ima potencial za ustvarjanje večkratnih senzoričnih izkušenj in povratnih informacij, ki vplivajo na različne vidike obdelave informacij in odziva pacientov. S pregledom literature so želeli ugotoviti kakšni so možni učinki vadbe z navidezno resničnostjo na ravnotežje pri pacientih s Parkinsonovo boleznijo. Rezultati nakazujejo potrebo po nadaljnjem razvoju te tehnologije, še posebej osredotočenost na imerzivno obliko navidezne resničnosti, ki še posebej kaže potencial za izboljšanje ravnotežja pri posameznikih s Parkinsonovo boleznijo.

V naslednjem izvirnem znanstvenem članku so avtorji ocenjevali držo stopala in gibljivost kolčnega sklepa pri vrhunskih rokometnih in nogometnih igralcih ter raziskovali možne povezave med temi merami. S primerjavami razlik v indeksih med tremi skupinami preiskovancev, so z meritvami pridobili zanimive rezultate, ki izpostavljajo potrebo po nadaljnjem poglabljanju raziskav.

Naslednji prispevek, pregledni članek, raziskuje pozitivne učinke gibalne/športne aktivnosti starejših s srčno-žilnimi obolenji na arterijski krvni tlak. Na podlagi 15 izbranih študij je bilo ugotovljeno, da ima gibalna/športna aktivnost, ne glede na obliko vadbe, prilagojene starejši populaciji, pozitivne učinke na arterijski krvni tlak starejših srčno-žilnih bolnikov.

Še en pregledni članek raziskuje pozitivne učinke različnih oblik vadbe pri obvladovanju sindroma kronične utrujenosti/mialgičnega encefalomielitisa med delovno aktivno populacijo. Avtorji ugotavljajo, da izbrane študije dosledno dokazujejo pozitivne vplive tako na telesno delovanje kot tudi zmanjševanje stopnje utrujenosti pri zaposlenih posameznikih s sindromom kronične utrujenosti.

Rubrika Tehnična poročila prinaša zanimiv prispevek pereči problematiki preobremenitvenih poškodb pri populaciji mladih športnikov. V zadnjem

času se je močno povečalo udejstvovanje mladostnikov v športu na načine, ki presegajo osnovno rekreativno raven. Žal je ena od posledic tega trenda tudi zaskrbljujoča porast preobremenitvenih sindromov. Članek na pregleden način obravnava tako ugotovljene dejavnike tveganja, kot tudi patofiziologijo in možne preventivne ukrepe pri mladih športnikih. Pomemben poudarek članka predstavlja priporočilo, da je potrebno več energije usmeriti v preventivno delovanje. To naj se zavzema za preprečevanje zgodnje specializacije v športu in spodbuja ustrezen počitek. Za ohranjanje mentalnega in telesnega zdravja avtorji priporočajo raznovrstnost gibalne/športne aktivnosti, omejitev števila ur treninga in izdelan sistem pomoči v primerih zaznanih težav.

Številko revije zaključujejo poročila iz dveh konferenc in sicer 28. letnega kongresa Evropskega združenja športnih znanosti, ki ga je od 4. do 7. julija 2023 v Parizu gostil Francoski inštitut za šport (INSEP) ter že 12. izdaje mednarodne znanstvene in strokovne konference Otrok v gibanju, ki je od 2. do 4. oktobra 2023 pod naslovom »Spremenimo igro – s sodobnimi pristopi nazaj k osnovam« potekala v Portorožu, Slovenija.

Vljudno vabljeni k branju celotnih prispevkov, tehničnega poročila ter poročil dogodkov.

Dr. Matej Plevnik,
urednik

Review article
received: 2023-07-03
DOI: https://doi.org/10.35469/ak.2023.394
UDC: 796.413:616.858

ENHANCING BALANCE IN PARKINSON'S DISEASE PATIENTS: A COMPREHENSIVE LITERATURE REVIEW ON THE EFFICACY OF EXERCISE IN AN ENRICHED ENVIRONMENT

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ABSTRACT

Various physiotherapeutic methods and approaches play a significant role in the treatment of patients with Parkinson's disease, including the use of enriched environments. Virtual reality (VR) as a type of enriched environment has the potential to create multiple sensory experiences and feedback, influencing various aspects of the patient's information processing and response. The suitability for home use and the considerable impact on motivation highlight its advantages over alternative approaches. The objective of this review is to investigate the impact of VR-based exercise on balance outcomes among individuals with Parkinson's disease. The inclusion criteria consisted of randomized controlled trials (RCTs) that examined the effects of exercise in a VR environment on individuals' static and dynamic balance outcomes. In order to gather relevant studies, we conducted a comprehensive search across three databases. From a dataset of 625 records, we conducted a comprehensive full-text screening based on specific inclusion and exclusion criteria. This process resulted in the inclusion of 14 RCTs in our review. The emerging evidence regarding exercising in a VR environment does not definitively prove its superiority over standard exercise routines. However, studies have demonstrated that both the experimental and control groups showed comparable improvements in enhancing static and dynamic balance among individuals with

Parkinson's disease. The comparable improvements in balance observed between the experimental and control groups signify the potential effectiveness of VR-based exercises. This underscores the encouragement for further development in this technology, particularly focusing on fully immersive VR environments, which may yield superior effects in enhancing balance among individuals with Parkinson's disease.

***Keywords**: virtual reality, Parkinson's disease, balance, rehabilitation.*

UČINKOVITOST VADBE V OBOGATENEM OKOLJU ZA IZBOLJŠANJE RAVNOTEŽJA PRI PACIENTIH S PARKINSONOVO BOLEZNIJO: PREGLED LITERATURE

IZVLEČEK

Pri zdravljenju Parkinsonove bolezni imajo pomembno vlogo različne fizioterapevtske metode in pristopi, med katere spada tudi uporaba obogatenega okolja. Navidezna resničnost kot vrsta obogatenega okolja ima potencial za ustvarjanje večkratnih senzoričnih izkušenj in povratnih informacij, ki vplivajo na različne vidike obdelave informacij in odzivov pacientov. Poleg tega je prednost vadbe v obogatenem okolju tudi v tem, da je primerna za domačo uporabo in deluje spodbudno. Namen tega dela je s pregledom literature ugotoviti, kakšni so učinki vadbe z navidezno resničnostjo na ravnotežje pri pacientih s Parkinsonovo boleznijo. Vključitvena merila vsebujejo randomizirane kontrolirane raziskave, ki proučujejo učinke vadbe v okolju navidezne resničnosti na statične in dinamične rezultate ravnotežja posameznikov. Za zbiranje relevantnih raziskav smo obsežno preiskali tri baze podatkov. Med 625 zapisi smo temeljito preverili celotna besedila, upoštevajoč določena merila za vključitev in izključitev. S pomočjo tega postopka smo dobili 14 raziskav, ki smo jih vključili v svoj pregled. Na podlagi vključenih raziskav smo ugotovili, da nimamo dovolj dokazov, da bi lahko trdili, da vadba v obogatenem okolju pomembno izboljša ravnotežje pri pacientih s Parkinsonovo boleznijo v primerjavi s tradicionalno vadbo. Raziskave so pokazale, da sta eksperimentalna in kontrolna skupina pokazali primerljive izboljšave v statičnem in dinamičnem ravnotežju pri posameznikih. Primerljive izboljšave v ravnotežju, opažene med eksperimentalno in kontrolno skupino, kažejo potencialno učinkovitost vadb v okolju navidezne resničnosti. To potrjuje potrebo po nadaljnjem razvoju te tehnologije, še posebej osredinjenost na imerzivno obliko navidezne resničnosti, ki ima potencial za izboljšanje ravnotežja pri posameznikih s Parkinsonovo boleznijo.

***Ključne besede**: navidezna resničnost, Parkinsonova bolezen, ravnotežje, rehabilitacija*

INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disorder characterized by the degeneration of dopaminergic neurons in the substantia nigra of the basal ganglia (Hague, Klaffke, & Bandmann, 2005). This results in a dopamine deficiency that manifests itself in primary motor signs and symptoms such as the slowing of movements, tremor, and increased muscle tone that worsen over time and negatively affect patients' balance, gait, functional mobility, and consequently quality of life (Goldman & Tanner, 1998; Müller et al., 2019). The main motor features are bradykinesia, rigidity, tremor, and postural instability (Ball, Teo, Chandra, & Chapman, 2019; Roytman et al., 2023). Parkinson's disease is not only a motor disorder, but also presents a variety of non-motor symptoms (e.g., disturbances in mood, cognition, and sleep) that often affect quality of life more than motor symptoms (Postuma, 2017).

Physiotherapy plays an important role in the treatment of Parkinson's disease. The use of various physiotherapy methods can improve balance and help patients become more independent. In addition to traditional rehabilitation methods, virtual reality (VR) is becoming an increasingly popular method for Parkinson's patients (Schultheis & Rizzo, 2001). Traditional rehabilitation methods include various exercise programs involving balance exercises, such as standing on one leg with eyes closed/open, stepping exercises, dual-task exercises, seated and standing exercises, and exercises on a balance beam or other challenging surfaces. Later, balance exercises are supplemented with perturbation (Lewis & Rosie, 2012).

VR as a form of enriched environment holds the potential of a breakthrough technology for non-physical rehabilitation by providing multisensory information and more realistic simulations to improve patient rehabilitation outcomes (Šlosar, Peskar, Pišot, & Marusic, 2023; Meulenberg, de Bruin, & Marusic, 2022). This computer-generated environment is not static, but responds to the user's movements, gestures, and verbal commands, giving the user the feeling of really being in this virtual world (Lewis & Rosie, 2012). With devices that allow visual or audio interaction between a person and VR, the person can imagine being part of the virtual environment. It can appear in it in the form of an imaginary object. In response to the user's task (in the case of physical therapy, movement), the computer program generates changes in the virtual environment through its sensors that provide feedback on performance.

VR can stimulate the user's movement and cognitive processes, increasing the patient's chances of regaining lost motor skills. It can also be used for bal-

ance training and visual feedback (Mirelman, Maidan, & Deutsch, 2013). The use of VR has a long-term effect on patients, as it can prevent or slow the progression of movement disorders (Allen, Sherrington, Paul, & Canning, 2011). Originally designed for recreation and entertainment, the systems are now also used for therapeutic purposes due to their low cost, high availability, and portability (Kong et al., 2016). These devices include the Sony Playstation, Nintendo Wii, and Microsoft Xbox 360 Kinect, also known as exergames. VR encourages patients to make lifestyle changes and incorporate exercise into their daily lives. In addition, patients can use these devices at home. Due to their low cost, these devices are also suitable as rehabilitation aids for patients from lower socioeconomic backgrounds (Yong Joo et al., 2010). VR ranges from non-immersive to fully immersive, according to the degree of immersiveness provided (Piron et al., 2010). Non-immersive VR refers to a virtual experience through a computer, but also allows the user to remain aware of and in control of their physical environment (Henderson et al., 2013). Common technologies in this category include gaming consoles like PlayStation, Xbox 360, and Nintendo Wii, which integrate exercise actions with gaming mechanics. To simplify the study of the effects of these interventions, Šlosar et al. (2022) categorized them as PC-exergames. Research suggests that these systems hold promise in ameliorating symptoms in neurological disorders and fostering cognitive and motor improvements, including in Parkinson's disease (Maggio et al., 2019). On the other hand, fully immersive VR enables natural interaction with the environment by using the entire body of the user, who thus becomes an active part of the 3D environment (Tieri, Morone, Paolucci, & Iosa, 2018). The most common types of VR technologies are the HMD (Head-Mounted Display) and CAVE (Cave Automatic Virtual Environment) systems. When physical activity is incorporated into interventions within a fully immersive VR environment, Šlosar et al. (2022) suggested the term VR-exergames to name and further investigate these interventions.

For a more precise analysis of intervention effects, we applied the taxonomy introduced by Šlosar et al. (2022) to classify the studies we gathered. In recent years, significant progress has been made in the field of technology and rehabilitation methods. Therefore, a literature review is needed to update the results of the previous literature review, (Chen, Gao, He, & Bian, 2020; Lei et al., 2019) in the field of VR training to improve balance in patients with Parkinson's disease. The aim of this review is to and analyze the existing studies to determine whether exercises in enriched environments improve balance ability in patients with Parkinson's disease.

METHODS

A literature search was performed across PubMed, PEDro, and Google Scholar (first 100 results) utilizing various keywords including “virtual reality,” “VR,” “Parkinson’s disease,” “balance,” “rehabilitation,” and their synonymous terms to locate relevant articles. Supplement A includes the distinct search strings employed for each database.

The inclusion criteria to detect all the relevant articles were (i) The subjects of the study were Parkinson’s disease patients who had been formally diagnosed by a hospital or by internationally recognized diagnostic criteria. There were no restrictions on gender, course of disease, or severity of the disease; (ii) randomized controlled trials (RCTs); (iii) studies in which the experimental group underwent PC- or VR-based exercise interventions; (iv) studies in which outcomes were related to balance, i.e., RCTs that observed whether balance improved in the experimental group at the end of treatment. The exclusion criteria comprised publications prior to 2010, RCTs not available under open access, irrelevant findings, non-English language studies, and those lacking a control group. In line with the Schoneburg et al. (2013) study, balance function is associated to four posture systems: static balance, dynamic balance, reactive posture adjustment, and expected posture adjustment. Considering their substantial impact on balance among Parkinson’s patients, our primary emphasis was on assessing static and dynamic balance as the primary outcomes.

The screening process commenced by evaluating the titles and abstracts of the studies, identifying those most relevant to our topic. The second phase involved examining the full texts to ascertain if they met the aforementioned inclusion criteria. The retrieved studies were then classified based on the taxonomy proposed by Šlosar et al. (2022): PC-exergame – studies conducted in non-immersive environments involving movement; PC-no-exergame – studies conducted in non-immersive environments without movement; VR-exergame – interventions fully immersing participants in a virtual environment while involving movement; VR-no-exergame – studies wherein participants were fully immersed in a virtual environment without movement.

RESULTS

Study selection and characteristics of included studies

The initial search retrieved a total of 625 articles (480 from PubMed, 100 from Google Scholar, and 45 from PEDro). After deduplication, 35 articles were excluded. Subsequently, 27 articles were excluded based on titles and 3 based on abstracts, leaving 14 articles for thorough evaluation as potential inclusions. Figure 1 illustrates the comprehensive inclusion and exclusion process of the articles.

All participants were diagnosed with Parkinson's disease at different disease stages: 4 trials reported Hoehn and Yahr stages 1 to 3, 7 trials reported Hoehn and Yahr stages 2 to 3, 1 trial reported Hoehn and Yahr stages 2 to 4, and 2 trial did not report any stage. All retrieved studies (van den Heuvel et al., 2013; Lee et al., 2015; Shih, Wang, Cheng, & Yang, 2016; Yang, Wang, Wu, Lo, & Lin, 2016; Gandolfi et al., 2017; Ribas, Alves da Silva, Corrêa, Teive, & Valderramas, 2017; Santos, Machado, Santos, Ribeiro, & Melo, 2019; Tollár, Nagy, & Hortobágyi, 2019; Liao, Yang, Wu, & Wang, 2015; Liao, Yang, Cheng, et al., 2015; Pazzaglia et al., 2020; Yen et al., 2011; Shen & Mak, 2014) were categorized as PC-exergame studies, excluding Feng et al. (2019). Feng et al. (2019) lacked sufficient intervention details, such as specific performance methods, exercise intensity progression, and supervision information during training. As a result, we included 13 studies in the PC-exergames category, while no studies were found for the other categories.

Effects of virtual reality training on static and dynamic balance

In all 14 studies, outcome measures used for balance assessment included the Berg Balance Scale (BBS), Limits of Stability (LOS), One-Legged Stance Test (OLS), the Activities-Specific Balance Confidence Scale (ABC), and the Sensory Organization Test (SOT). The majority of the studies used the BBS as the primary outcome measure for functional balance. The results are shown in Table 1. Several studies (Feng et al., 2019; Lee et al., 2015; Gandolfi et al., 2017; Tollár et al., 2019; Liao, Yang, Cheng, et al., 2015; Pazzaglia et al., 2020) demonstrated significant improvements in static and dynamic balance among participants in the experimental group. Ribas et al. (2017) and Yen et al. (2011) also concluded that the experimental group exhibited statistically signif-

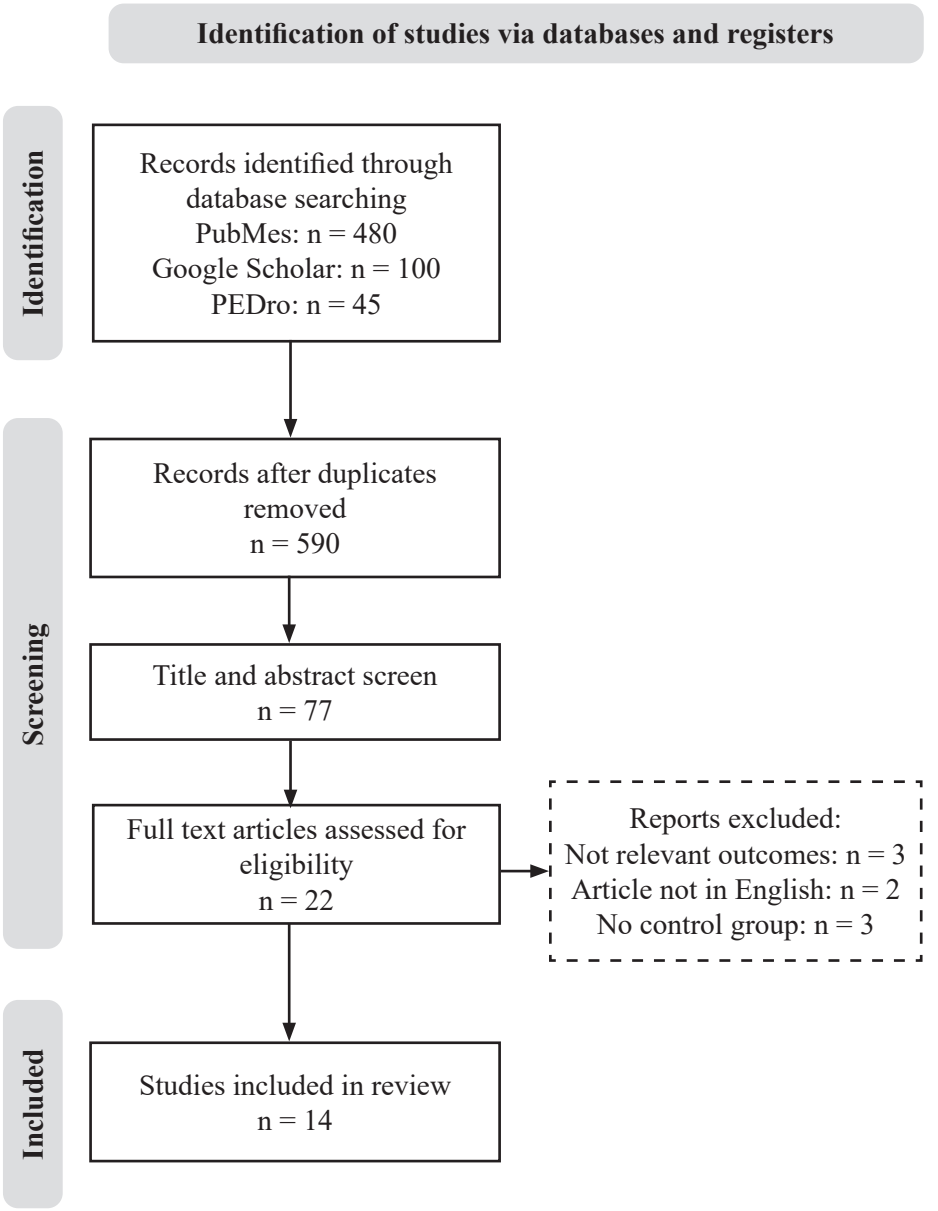

Figure 1: Flow chart depicting the selection process of identified articles

icant progress in maintaining balance compared to the control group; however, the progress was not sustained over time. Liao, Yang, Wu, et al. (2015) found significant improvements in balance among both the experimental group and the group that performed traditional exercises, when compared to the control group. Shen & Mak (2014) reported that participants in the experimental group showed a significantly increased level of self-confidence in maintaining balance, as assessed by the self-assessment ABC test. Shih et al. (2016) found that the experimental group achieved improved postural stability compared to the control group, which followed a traditional balance training program. Both exercise programs were effective in improving functional balance in patients with Parkinson's disease. In the study by van den Heuvel et al. (2013) the results did not show a significant improvement in balance among the participants. Similarly, Yang et al. (2016) found that balance improved equally in both groups, with no significant differences observed between them. Santos et al. (2019) also reported that a combination of traditional exercise and Nintendo Wii training, as well as each individual intervention with an equal amount of physiotherapy, led to balance improvement. However, when analyzing all the results, no statistically significant differences were found between the two groups.

Table 1: Summary of the 14 included studies

Study	Population	Intervention		Duration time	Outcomes and results
		Experimental group	Control group		
van den Heuvel et al. (2013)	n = 33	Visual feedback training, which was explicitly integrated in each workstation. Workstations consisted of a flat-panel LCD monitor connected to a PC containing, interactive dynamic balance exercises. (n = 17)	Conventional balance training (n = 16)	60 min / 10 treatment sessions / 5 weeks	There were no statistically significant differences between groups in change scores for BBS and SLS test.
N.-Y. Lee et al. (2015)	n = 20	Dance exercise with Nintendo Wii + neurodevelopment treatment + functional electrical stimulation (n = 10).	Neurodevelopment treatment + functional electrical stimulation (n = 10).	30 min / 5 times per week / 6 weeks	Balance had significantly improved in the EXP group while CON group showed no significant improvement. Balance was measured by BBS.
Shih et al. (2016)	n = 20	Balance-based exergaming intervention using the Kinect sensor. (n = 10)	Conventional balance training (n = 10)	50 min / 2 times per week/ 8 weeks	Both training programs improved functional balance in people with PD according to the results of BBS tests. There were no significant differences between the groups.
Yang et al. (2016)	n = 23	Home-based balance training system included touchscreen computer and a wireless balance board. (n = 11)	Conventional balance training (n = 12)	50 min / 2 times per week / 6 weeks	After training, both groups performed better in the BBS at post-test and follow-up than at pretest. No significant differences were found between these two groups at post-test and follow-up.

Study	Population	Intervention		Duration time	Outcomes and results
		Experimental group	Control group		
Gandolfi et al. (2017)	n = 76	Balance training with Nintendo Wii and balance board. (n = 38)	Sensory Integration Balance Training (n = 38)	50 min / 3 days per week / 7 weeks	Significant between-group differences were found for BBS scores. EXP group – progress, according to the BBS
Ribas et al. (2017)	n =20	The exergaming intervention consisted of Wii Fit games. The device used was a Nintendo video game console with a Wii Balance Board (n = 10)	Conventional exercise program (Warming, stretching active and resistance exercises) (n = 10)	30 min / 2 times per week / 12 weeks	Significant improvement in balance relative to BBS in the EXP group; this benefit was not sustained after the 60-day follow-up.
Santos et al. (2019)	n = 45	EXP1 group Training with Nintendo Wii (n=15) EXP2 group: Training with Nintendo Wii + active assisted and resisted active movements, based on the PNF. (n = 15)	CON group: active assisted and resisted movements, based on the PNF and gait training. (n = 15)	50 min / 2 a week / 8 weeks	There was no statistically significant difference between EXP1, EXP2 group and CON group according to the BBS.
Feng et al. (2019)	n = 28	Balance training with Microsoft Xbox 360 Kinect (n = 14)	Traditional rehabilitation training (warm up exercises, balance exercises, exercises for physical condition and coordination) (n = 14)	45 min / 5 times per week / 12 weeks	Significant improvement in BBS scores in both groups; BBS were better in EXP group than in CON group.

Study	Population	Intervention		Duration time	Outcomes and results
		Experimental group	Control group		
Tollár et al. (2019)	n = 74	EXP1 group: Exergames used the visual feedback modules of the Xbox 360 core system. (n = 25) EXP2 group: stationary cycling (CYC) patients participated in a spinning class. (n = 25)	CON group: Wait-listed CON group continued with their habitual activity. (n = 24)	60 min / 5 times per week / 5 weeks	EXP1 group: patients had better results in BBS score compared to the EXP2 group.
Liao, Yang, Wu, et al. (2015)	n = 36	EXP1 group: Training with Nintendo Wii (strength and balance exercises) (n = 12) EXP2 group: Traditional exercises such as stretching, strengthening, balance exercise, and treadmill training (n = 12)	CON group: did not undergo the structured exercise program but received fall-prevention education instead. (n = 12)	60 min / 2 times per week / 6 weeks	Both the EXP1 and EXP2 groups showed significant improvements in SOT test.
Liao, Yang, Cheng, et al. (2015)	n = 36	EXP1 group: Training with Nintendo Wii (strength and balance exercises) (n = 12) EXP2 group: traditional exercise (stretching, strengthening and balance exercises) (n = 12)	CON group: fall-prevention education (n = 12)	60 min / 2 times per week / 6 weeks	Patients in the EXP1 group had better results in the LOS and SOT test than participants in control group.

Study	Population	Intervention		Duration time	Outcomes and results
		Experimental group	Control group		
Pazzaglia et al. (2020)	n= 51	Exercise to improve balance with the NIRVANA system. (n = 25)	Conventional rehabilitation program (exercises of motor coordination, balance training, start and stop exercises, and walking training) (n = 26)	40 min / 3 times per week / 6 weeks	EXP group improvement in balance according to BBS scale scores compared to the CON group.
Yen et al. (2011)	n = 42	EXP1 group: The hardware system for balance training includes dynamic balance board LCD screen, and a personal computer. (n = 14)	CON group: They did not receive did not receive any physical therapy (n = 14)	30 min / 2 times per week / 6 weeks	According to the SOT test, the EXP1 group made a significant improvement compared to the CON group, but this improvement was not sustained.
		EXP2 group: conventional balance training, (n = 14)			
Shen & Mak, (2014)	n = 51	A computerized dancing system (KSD Technology Co. Ltd., Shenzhen, China) (n = 26)	Training that emphasized improving the strength of the hip (flexion, extension, and abduction) and knee (flexion and extension) (n = 25)	15–60 min / 5 times per week / 12 weeks	The ABC scale analysis showed that there were no significant differences between the two groups. The EXP group performed better on the SLS test.

Legend: BBS – Berg Balance Scale, ABC – activities-specific balance confidence scale, SLS – Single Leg Stance, SOT – Sensory Organization Test, LOS – Limits of Stability, EXP – experimental group, CON – control group, PNF – proprioceptive neuromuscular facilitation, PD – Parkinson disease

DISCUSSION

The literature review examining the impact of VR-based exercises on the static and dynamic balance outcomes of Parkinson's disease patients indicates that existing studies lack definitive evidence to establish the superiority of exercise in a virtual environment over standard exercise. The considerable variability in exercise methods makes it difficult to draw firm conclusions regarding the effect of PC-exergame training on the balance ability of Parkinson's disease patients.

Although most studies did not demonstrate the superiority of PC-exergames over standard exercise, a study by Liao, Yang, Cheng, et al. (2015) revealed that Wii Fit-based exercises were more effective than traditional exercise in improving dynamic balance. One potential explanation for improved balance lies in personalized therapy protocols tailored to meet individual therapeutic needs and preferences. Wii Fit exercises provide external feedback during training in both auditory and visual forms. The participants were able to make corrections based on feedback to enhance their motor performance. Some of the Wii Fit exercises require either attention or problem-solving ability. Lee et al. (2015) observed a similar positive impact when introducing an innovative training method for elderly individuals diagnosed with Parkinson's disease, employing Nintendo Wii dance games. Compared to the control group, balance of the experimental group was significantly enhanced. The experimental group received 30 more minutes of treatment per session comparing to control group and the difference in training time probably influenced the results. Another potential confounding factor in the study is that participants received traditional physiotherapy accompanied with Nintendo Wii. It is challenging to determine whether changes in clinical trials should be attributed to traditional balance training or VR.

Unlike the previously mentioned studies, van den Heuvel et al. (2013) did not integrate Nintendo Wii into their setup. Instead, they employed a mobile workstation setup equipped with a force plate for the intervention within the experimental group. However, this approach did not demonstrate superior effectiveness compared to conventional therapy.

The diversity of devices utilized in these studies poses a challenge in reaching definitive conclusions. Devices ranged from common gaming consoles like Nintendo Wii and Xbox Kinect to specialized rehabilitation systems such as the NIRVANA and the computerized dancing system (KSD Technology Co. Ltd., Shenzhen, China). Moreover, the varied frequency (ranging from 2 to 5 times per week) and duration (lasting 5 to 12 weeks) of training sessions add complexity in establishing effective protocols. This wide array of intervention

types and frequencies significantly contributes to result heterogeneity, presenting difficulties in establishing conclusive findings. To reduce variability in results, future studies should research tailored interventions for different diseases stages. It is well known that Parkinson's disease patients often have a preserved ability to cycle (Licen, Rakusa, Bohnen, Manganotti, & Marusic, 2022). This represents a unique aspect of their motor function that must be considered when designing research studies. If the ability to cycle is preserved in Parkinson's disease, comparing the effectiveness of exergame / VR interventions with traditional cycling could be problematic because of the potential overlap in benefits and the need for differentiated evaluation methods to distinguish the respective effects.

Reviewing the literature it emerges that the PC-exergame technology for home-based training can be an effective option, particularly for individuals with limited access to rehabilitation centers and hospitals and could be used as a low-supervision home-base technology to obtain a therapeutic effect independently (Yang et al., 2016). However, a notable concern with home-based exercise lies in the possibility of users adopting compensatory movements to boost game performance. This inclination might lead patients to prioritize achieving high game scores over enhancing movement quality, potentially diminishing the genuine training effects. Before introducing computer games at home, it's essential to prevent compensatory movements from affecting game performance. Supervised exercises by a physiotherapist can ensure safety and discourage compensatory actions. This supervision is especially vital for older adults unfamiliar with new technologies.

Literature review is subject to certain limitations that should be considered. A significant limitation is the inclusion of various forms of exercise in the VR-exergaming category. In the future, as more studies become available, it would be advisable to perform sub-analyses that differentiate between different types of exercises. For instance, the Shen & Mak (2014) study incorporated dancing, while others focused on strength and balance exercises.

We included studies involving participants clinically diagnosed with Parkinson's disease, without any limitations on gender, age, disease duration or severity, and these studies exhibited variations in the types of technology employed and the duration of interventions. These factors may have introduced biases in the results and hindered direct comparisons. Future studies with improved technology and research methodologies are necessary to address the limitations and provide clearer insights into the effectiveness of exercise in enriched environments Additionally, these future investigations should incorporate innovative technologies that enable a holistic understanding of motor control strategies in

Parkinson's disease (Marusic et al., 2023), thus advancing our comprehension of the condition's intricacies.

CONCLUSIONS

The literature review encompasses scientific publications that explore the use of VR as a treatment modality for individuals with Parkinson's disease, specifically focusing on the impact of training in an enriched environment on balance improvement. Some findings (although limited) suggest that exercise in an enriched environment can yield comparable outcomes to standard rehabilitation approaches, making it a viable option for balance rehabilitation in clinical settings. Additionally, it can serve as an adjunctive technology in the overall treatment plan for individuals with Parkinson's disease, aiming to enhance balance outcomes.

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Original scientific article
received: 2023-07-04

DOI: https://doi.org/10.35469/ak.2023.395
UDC: 796.322

FOOT POSTURE INDEX AND HIP JOINT ROTATION MOBILITY IN HANDBALL AND SOCCER PLAYERS

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ABSTRACT

Purpose: *To assess the foot posture and hip joint mobility of elite handball and soccer players and to investigate possible correlations between these measurements.*

Methods: *We compared the differences in means of Foot Posture Index (FPI), passive hip internal (IR), and external (ER) rotation range of motion (ROM) between three groups of male subjects (17 handball players, 17 soccer players, and 16 non-athletes). The Kruskal-Walli's test and post-hoc pairwise comparison with the Mann-Whitney U test were used to determine the differences between the group means, and associations between variables were analyzed with Spearman's correlation coefficient.*

Results: *No significant differences in the mean FPI were found between the soccer players (1.3 ± 2.9), handball players (0.7 ± 2.1), and the control group (1.7 ± 2.5) ($p > 0.05$). Similarly, no significant difference was found between the groups in the hip ER ROM. In contrast, a significantly lower ($p < 0.05$) hip IR ROM was observed in the soccer players (30.6° ± 5.3°) compared to the handball players (41.0° ± 8.1°) and the control group (41.1° ± 6.4°). A weak positive correlation was only observed between the FPI and hip IR ROM in the soccer players (ρ: 0.36, $p = 0.035$).*

Conclusions: *Handball and soccer players show a tendency toward less pronated feet compared to non-athletes, but the differences are not significant and the mean FPI values are still within the range of normal foot posture. The range of hip IR seems to be*

reduced in soccer players and weakly, but significantly and positively associated with the FPI value, which needs to be further investigated in future studies.

***Keywords**: foot shape, hip mobility, soccer players, handball players*

INDEKS DRŽE STOPALA IN GIBLJIVOST ROTACIJE KOLČNEGA SKLEPA PRI IGRALCIH ROKOMETA IN NOGOMETA

IZVLEČEK

***Namen:** Oceniti držo stopala in gibljivost kolčnega sklepa pri vrhunskih rokometnih in nogometnih igralcih in raziskati mogoče povezave med temi merami.*

***Metode:** Primerjali smo razlike v povprečnem indeksu drže stopala (FPI) ter pasivnega obsega giba zunanje (ZR) in notranje rotacije (NR) rotacije kolka med tremi skupinami moških preiskovancev (17 rokometašev, 17 nogometašev in 16 gibalno netreniranih). Za ugotavljanje razlik povprečji med skupinami smo uporabili test Kruskal-Wallis in jih naknadno parno primerjali z U-testom Mann-Whitney. Za analizo povezanosti spremenljivk je bil uporabljen Spearmanov koeficient korelacije.*

***Rezultati:** Ni bilo ugotovljenih statistično pomembnih razlik v povprečnem FPI ($p > 0,05$) med skupino nogometašev (1,3 ± 2,9), rokometašev (0,7 ± 2,1) in kontrolno skupino (1,7 ± 2,5). Prav tako nismo ugotovili pomembne razlike med skupinama glede obsega giba ZR kolka. Nasprotno pa smo pri nogometaših (30,6° ± 5,3°) opazili značilno manjši ($p < 0,05$) obseg giba NR kolka v primerjavi z rokometaši (41,0° ± 8,1°) in kontrolno skupino (41,1° ± 6,4°). Šibko pozitivno korelacijo smo zaznali le med FPI in obsegom giba NR kolka pri nogometaših (ρ: 0,36, $p = 0,035$).*

***Zaključki:** Rokometaši in nogometaši kažejo težnjo po manj proniranih stopalih v primerjavi s športno netreniranimi posamezniki, vendar so razlike neznačilne in srednje vrednosti FPI še vedno znotraj mej normalne oblike stopal. Zdi se, da je pri nogometaših obseg notranje rotacije kolka zmanjšan ter šibko, vendar značilno in pozitivno povezan z vrednostjo FPI, kar bi bilo v prihodnje smiselno podrobneje proučiti.*

***Ključne besede**: oblika stopala, gibljivost kolka, nogometaši, rokometaši*

INTRODUCTION

The foot and ankle complex provides a kinetic link between the ground and the lower extremity that is essential for gait and other activities of daily living (Brockett & Chapman, 2016). Its pathological biomechanics could alter the mechanism of the proximal joints of the lower extremity, especially the knee and hip joints (Gross, 1995), the effect of which is enhanced during athletic activities. There is evidence that increased foot pronation causes mechanical changes in the lower extremities that may overload the knee and hip (Mei, Gu, Xiang, Baker, & Fernandez, 2019). People with foot pronation also show a greater range of motion (ROM) in the barbell squat, with increased flexion in the hip, knee, and ankle joints, as well as greater hip adduction causing knee valgus, which is associated with hip internal rotation (Lu, Li, Rong, Baker, & Gu, 2022).

Both handball and soccer involve high-intensity activities such as running, jumping, cutting, sprinting, lateral and backward movements (Drust, Atkinson & Reilly, 2007; Michalsik, Aagaard & Madsen, 2015), which place a great load on the lower extremities, especially the ankles. Dayakidis and Boudolos (2006) point out that cutting maneuvers and reversal movements generate relatively large forces in the vertical and mediolateral directions associated with the supination of the hindfoot, which can lead to an increased risk of ankle sprains. Ankle injuries are one of the most common types of injuries in both handball and soccer (Kolokotsios, Drousia, Koukoulithras, & Plexousakis, 2021; Martín-Guzón et al., 2022). Most of these injuries involve lateral sprains resulting in a tear of the anterior talofibular ligament (Fong, Hong, Chan, Yung, & Chan, 2007). Repetitive movement patterns typical of a particular sport may result in altered static and dynamic foot behavior, with one foot type predominating over the other. There is evidence that swimmers and volleyball players have a tendency toward the more pronated foot type (De Groot et al., 2012; Lopezosa-Reca, Gijon-Nogueron, Garcia-Paya, & Ortega-Avila, 2018) and handball players have a tendency toward the supinated foot type (Martínez-Nova et al., 2014), while no predominant foot type has been found in soccer players (Lopezosa-Reca et al., 2018).

Non-optimal lower leg mechanics in situations where the entire lower extremity is heavily loaded with body weight, such as fast cutting maneuvers and/or landing on one foot, may therefore affect both the ankle and hip joints. However, there is a considerable lack of published studies on this topic. The results of L'Hermette, Polle, Tourny-Chollet, and Dujardin (2006) show that years of frequent handball training can have a negative impact on hip mobility.

The aim of this study was therefore to investigate foot posture and hip joint mobility in elite handball and soccer players. Two main objectives were set: 1) to find differences in the Foot Posture Index (FPI) and in the hip rotation ROM among the two groups of athletes and the group of non-athletes, and 2) to find possible correlations between the FPI and hip rotation ROM.

METHODS

Participants

The study was conducted with a sample of 50 male participants from three different groups. The handball group consisted of 17 professional handball players (22.4 ± 3.6 years, 185.7 ± 4.7 cm, 85.7 ± 9.2 kg), the soccer group of 17 professional soccer players (25.9 ± 4.1 years, 183.8 ± 5.0 cm, 78.1 ± 5.9 kg), and the control group consisted of 16 non-athletes (25.4 ± 4.1 years, 181.9 ± 5.4 cm, 86.8 ± 12.6 kg) who were only sporadically engaged in recreational physical activity. The participants in the soccer and handball groups were top athletes who completed at least two training sessions per day on most days of the week and took part in at least one match per week.

Subjects who had lower limb injuries, pain, or swelling at the time of measurement or who had undergone lower limb surgery in the last three months were not eligible to participate in the study.

The handball players were members of the Trimo Trebnje handball club and the soccer players were members of the Olimpija Ljubljana soccer club. In the control group, the sample was drawn at random. Participants were included who were willing to cooperate and whose age corresponded to that of the other groups. Only people who were not involved in organized sports activities were included in the control group. The study was approved by the National Medical Ethics Committee of the Republic of Slovenia (No.: 0120-375/2017/3, date approved: 13.11.2017) and carried out in accordance with the Declaration of Helsinki. Each participant was required to sign a written informed consent before participating in this study.

Foot Posture Assessment

The Foot Posture Index (FPI) was used to assess the anatomical and morphological properties of both feet in a weight-bearing position according to the original instructions for the use of the tool (Redmond, 2005). Each foot was evaluated separately by a physiotherapist skilled in the use of the FPI tool. During the assessment, the subject stood in a relaxed bilateral position on firm ground in a well-lit room. The investigator assessed all six clinical criteria of the FPI (Redmond, 2005):

1. Talar head palpation, 2. Supra and infra lateral malleolar curvature, 3. Calcaneal frontal plane position, 4. Prominence in the region of the talonavicular joint, 5. Congruence of the medial longitudinal arch, 6. Abduction/adduction of the forefoot on the rearfoot. Each criterion was valued with one of the following values: -2 (highly supinated), -1 (supinated), 0 (neutral), +1 (pronated), +2 (highly pronated), and summated to calculate the FPI value for each foot, ranging from -12 (highly supinated) to +12 (highly pronated) (Redmond, 2005). The assessment of each subject took approximately 2 minutes to complete. FPI values ranging from +1 to +7 were considered normal (Redmond, Crane & Menz, 2008).

Measurements of the Hip Joint External and Internal Rotation

Bilateral measurements of passive hip external (ER) and internal rotation (IR) range of motion (ROM) were performed according to a standard protocol using a universal goniometer (Jakovljević & Hlebš, 2011). The subject lay prone on an examination table, with the hip in a neutral position (0°) and the knee flexed at 90°. The center of the goniometer was placed over the basis of the patella, its stationary arm parallel to the floor, and the moving arm aligned with the longitudinal axis of the tibia. The leg was passively rotated inward and outward three times by the examiner. The subject's pelvis was manually stabilized against the table by a second examiner to prevent it from tilting and to detect the anatomical limit of joint motion.

Statistical Analysis

Descriptive statistics with means and standard deviations were used to present the demographic characteristics of the groups. The normality of the data distribution was tested using the Shapiro-Wilk test. Since a great majority of the measured parameters were not normally distributed, the non-parametric Kruskal-Wallis test (K-W test) was used to analyze differences in the means of the three groups. In case of an overall significant difference, a post-hoc pairwise comparison of means was made using the Mann-Whitney U test. Spearman's correlation coefficient (ρ) was calculated to evaluate the association between the FPI values and the hip rotational ROM (IR and ER). The significance level was set at $p < 0.05$ for a two-tailed test. All the values are presented as mean ± standard deviation, unless stated otherwise.

RESULTS

The data on the basic characteristics of the sample (age, body height, and weight) and all the measured parameters exhibited non-normal distribution ($p < 0.05$), except for the FPI values in the control group ($p > 0.05$). The soccer group had a significantly lower body weight compared to the handball ($p = 0.024$) and control ($p = 0.033$) groups, whereas no significant differences were detected among the groups for age and body height (Table 1).

Table 1: Basic characteristics of the sample

Variable	Handball (n=17)	Soccer (n=17)	Control group (n=16)	K-W test (p-value)
Age (years)	22.4 ± 3.6	25.9 ± 4.1	25.4 ± 4.1	p = 0.076
Height (cm)	185.7 ± 4.7	183.8 ± 5.0	181.9 ± 5.4	p = 0.142
Weight (kg)	85.7 ± 9.2	78.1 ± 5.9*	86.8 ± 12.6	p = 0.011

Legend: * – Significantly different from both the control and handball groups at $p < 0.05$

The mean FPI values and hip ROMs for all the groups are presented in Table 2. The highest mean FPI was obtained in the control group (1.7 ± 2.5) and the lowest in the handball group (0.7 ± 2.1). There were no significant differences between the three groups ($p = 0.450$).

However, there was a significant difference between the groups in the internal rotation ROM ($p < 0.001$). The pairwise comparison showed significantly lower internal rotation ROM in the group of soccer players (30.6° ± 5.3°) compared to both the handball group ($p < 0.001$) and the control group ($p < 0.001$).

Table 2: Mean values of FPI and hip rotation range of motion

	Handball group	Soccer group	Control group	K-W test (p-value)
FPI value (min / max)	0.7 ± 2.1 (-4 / +7)	1.3 ± 2.9 (-3 / +8)	1.7 ± 2.5 (-3 / +6)	0.450
Hip joint IR (min / max)	41.0° ± 8.1° (25° / 60°)	* 30.6° ± 5.3° (20° / 45°)	41.1° ± 6.4° (30° / 60°)	< 0.001
Hip joint ER (min / max)	39.9° ± 7.1° (25° / 50°)	39.4° ± 7.0° (25° / 50°)	42.2° ± 5.4° (30° / 50°)	0.294

Legend: FPI – Foot Posture Index, IR – internal rotation, ER – external rotation, * – different from the control group and handball group at $p < 0.001$

Table 3: Mean Foot posture Index values by criterion

Criterion	Handball group	Soccer group	Control group	K-W test (p-value)
Talar head palpation	0.03 ± 0.17*	0.38 ± 0.54	0.19 ± 0.53	0.008
Curves above/ below LM	0.21 ± 0.58	0.32 ± 0.58	0.34 ± 0.54	0.628
Inversion/ eversion calcaneus	-0.03 ± 0.57	0.09 ± 0.56	0.25 ± 0.61	0.153
Prominence TNJ	0.03 ± 0.38	-0.06 ± 0.48#	0.28 ± 0.57	0.016
Congruence MLA	0.00 ± 0.64	0.00 ± 0.94	0.19 ± 0.53	0.534
Abd/add forefoot/ rearfoot	0.47 ± 0.61	0.59 ± 0.65	0.44 ± 0.50	0.659

Legend: LM – lateral malleolus, TNJ – talonavicular joint, MLA – medial longitudinal arch, ABD – abduction, ADD – adduction, * – statistically significant difference vs. the Soccer group ($p < 0.05$), # – statistically significant difference vs. the Control group ($p < 0.05$)

A comparison of the six individual clinical criteria of the FPI showed that there were significant differences between the groups for the talar head palpation ($p = 0.008$) and the prominence of the talonavicular joint ($p = 0.016$) (Table 3). The pairwise comparison showed significant differences in the prominence of the talonavicular joint between the control group and the soccer group ($p = 0.017$), and in the position of the talar head between the soccer group and the handball group ($p = 0.006$).

For soccer players, a weak but significant positive correlation was found between the FPI values and IR (ρ: 0.36, $p = 0.035$) (Figure 1). No significant correlations were found between any other variables.

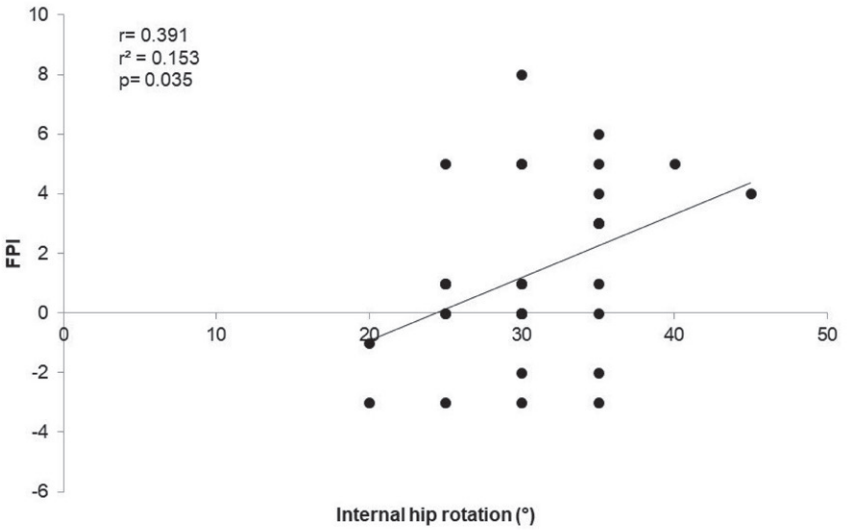

Figure 1: Spearman's correlation coefficients (ρ) between the FPI value and internal hip rotation range of motion in soccer players

DISCUSSION

Our results show that the mean FPI of the soccer players and their non-athlete peers is within the expected normal range (from +1 to +7) for their age (Redmond et al., 2008), while handball players are on the left edge, with a ten-

dency toward a more supinated foot type. However, the observed group differences were not significant. The soccer players had a significantly lower ROM of hip internal rotation than the other two groups, which was also weakly but significantly positively correlated with their FPI values. However, no significant correlation was found between the FPI and hip rotation ROM in handball players and non-athletes.

Compared to the main normative values of the FPI (Redmond et al., 2008), all our participants had lower mean FPI values (i.e. less pronation) than expected as has been shown to be the case in the healthy non-athletic adult population (aged 18-59 years; mean FPI = 4). The reason for this cannot be fully established, but some reasonable assumptions can be made. Based on the FPI data published by Scott, Menz, and Newcombe (2007) showing lower foot pronation in young adults (aged 20.9 ± 2.6 years; FPI = 2.54 ± 2.35) than in older people (aged 80.2 ± 5.7 years; FPI = 4.14 ± 3.86), it could be hypothesized that the lower foot pronation in our sample is due to their younger age. However, the more representative normative data from Redmond et al. (2008) do not support this hypothesis. On the contrary, their data show that the FPI scores exhibit a U-shaped relationship with age, i.e., greater foot pronation in minors under the age of 18 (mean FPI = 6) and again at older ages (mean FPI = 5) (Redmond et al., 2008). Thus, a more plausible explanation for the difference could be the difference in training status, as our sample consisted of elite athletes, whereas the normative data of Redmond et al. (2008) was based on a sample of non-athletes. It appears that the FPI decreases toward a less pronated or even supinated foot posture in people with different foot pathologies (Redmond et al., 2008). Since soccer and handball players are exposed to the daily overloading of their feet during their sporting activities, they might develop a pre-pathological decrease in foot pronation. This could also be the case in our control group, whose activity level we do not know exactly. Although the subjects did not exercise several times a week, their activity level was most likely higher than the average of the non-athlete population used in Redmond et al. (2008). In addition, there may be other unknown specific characteristics of our control group that we did not identify but that influenced the FPI results.

Although not significant, both the soccer and handball players showed a tendency to have less pronated feet than the control group. Handball players even showed a tendency to a supinated foot posture, while the other two groups showed a tendency to a more normal (i.e. slightly pronated) foot posture, which is almost consistent with the published FPI data from different sports (Table 4), including handball (Martínez-Nova et al., 2014) and soccer players (Lopezosa-Reca et al., 2018). Martínez-Nova et al. (2014) speculated that this could

be due to the constant rotations/pivoting and lateral displacements that cause inversion moments in the knee and hip joints of handball players. As shown in Table 4, there are large differences in FPI between sports. The difference is most pronounced in swimmers with highly pronated feet (FPI = 6.5 ± 2.0, Table 4). The intensity and pattern of mechanical loading on the feet of swimmers are the opposite of the forces generated in the feet of handball players or soccer players. Swimming is a non-weight-bearing activity under conditions of reduced gravity with essentially non-existent longitudinal compressive forces in the foot, which significantly reduces the need for muscle activity in the lower leg and foot. Liebenberg et al. (2011) have shown this by measuring the EMG amplitude of the lower limb muscles during running, which decreased linearly with the decrease in body weight transferred to the lower limbs.

Table 4: FPI values in various sports practitioners reported in the literature

Study	Sport	Age	Mean FPI
Kuo & Liu, 2017	basketball, volleyball, badminton, tennis	22.0 ± 3.0	3.5 ± 3.0
Cherati et al., 2016	futsal	22.1 ± 3.6	right foot: 4.9 ± 2.9 left foot: 4.7 ± 3.1
Martínez-Nova et al., 2014	basketball	32.1 ± 8.9	3.9 ± 4.1
	running	40.2 ± 7.3	2.9 ± 2.8
	handball	21.8 ± 3.2	-0.4 ± 6.9
Lopezosa-Reca et al., 2020	basketball	22.5 ± 3.9	2.7 ± 3.1
De Groot et al., 2012	volleyball	26.0 ± 5.5	4.0 ± 3.5
Lopezosa-Reca et al., 2018	swimming	17.2 ± 1.7	6.5 ± 2.0
	soccer	17.3 ± 1.0	2.3 ± 1.7

Handball players have been shown to have an increased risk of hip joint damage due to the repetitive and intense loading of the joint beyond the physiological limits of the cartilage that occurs in handball (L'Hermette et al., 2006). It has been shown that retired handball players (age 44.9 ± 4.7 years) have a lower ROM of the hip IR (16° ± 8°) compared to non-athletes of the same age

(IR = 23° ± 4°), most likely due to osteoarthritic changes in the hip joint caused by years of handball training (L'Hermette et al., 2006). We found no difference in hip rotation ROM in handball players compared to non-athletes, but our sample was much younger compared to participants in the study conducted by L'Hermette et al. (2006). However, we found a significantly lower ROM of passive IR of the hip in soccer players who are also exposed to specific overloads of the hip joint during soccer (Nunome, Asai, Ikegma, & Sakurai, 2002). Frequent lateral side-foot kicks, where the ball is kicked with the medial side of the foot, may cause repetitive exaggerated hip external rotation moments in the final phase of the kicks. This requires chronic overactivity, high muscle tone, and shortness of the external rotators of the hip, which can lead to a reduction of the internal rotation ROM and can have a long-term negative effect on the hip joint. The repetitive nature of movements that are specific to handball can lead to long-term alterations in the hip ROM, i.e. lower flexion and internal rotation and higher abduction, extension, and external rotation, and have been shown to have a strong association with an increased risk of developing premature hip OA in retired handball players (L'Hermette et al., 2006). Furthermore, lower hip internal and external rotation ROM have been shown to increase the risk of adductor strain in professional soccer players (Ibrahim, Murrell & Knapman, 2007).

A direct comparison of the ROM values of hip rotation among different studies is complicated not only by the age difference of the samples, but also by differences in hip position during goniometric measurements. Hip goniometry performed in the prone position with the hip extended has been reported to yield higher values than measurements performed in the seated position with the hip flexed (Han, Kubo, Kurosawa, Maruichi, & Maruyama, 2015; Hollman, Burgess & Bokermann, 2003). The review of data from some other studies, presented in Table 5, shows significant variability in the ROM of hip rotations acquired in a seated or supine position in athletes of different ages, so no clear conclusion can be drawn in this regard.

In the present study, no significant correlations were found between the FPI and hip rotation ROM, except for a weak but significant positive correlation between the FPI and hip internal rotation in soccer players. This is consistent with the findings of Souza, Pinto, Trede, Kirkwood, and Fonseca (2010), which suggest that there is a temporal coupling of rearfoot pronation with hip IR during walking. The fact that the pronation of the foot was only associated with hip IR in soccer players who also exhibited reduced ROM of the IR suggests that the tightness of the hip external rotators may have some influence on foot position. Coaches, kinesiologists, and physiotherapists should pay more attention

Table 5: Range of motion of the internal (IR) and external (ER) hip rotation in various sports practitioners

Study	Group	Age (years)	Body position	IR Hip Joint	ER Hip Joint
Hogg et al., 2018	basketball	19.4 ± 1.3	prone	28.7° ± 9.5°	39.9° ± 12.7°
	cross-country skiing			32.6° ± 7.2°	28.5° ± 6.2°
	golf			27.9° ± 7.7°	34.3° ± 6.0°
	soccer			26.2° ± 8.4°	35.3° ± 12.9°
	softball / baseball			29.4° ± 6.9°	34.5° ± 6.4°
	tennis			26.6° ± 8.9°	43.0° ± 11.6°
Hollman et al., 2003	running	36.6 ± 12.1	prone	50.3° ± 6.1°	43.0° ± 8.3°
			sitting	43.8° ± 4.7°	33.1° ± 5.2°
Kouyoumdjian et al., 2012	general population	39.1 ± 10.8	prone	35.3° ± 11.9°	41.8° ± 10.2°
			sitting	37.9° ± 8.4°	40.7° ± 7.6°
López-Valenciano et al., 2019	soccer	25.5 ± 5	prone	47.1° ± 8.0°	49.9° ± 9.8°

to the mobility of hip rotation in soccer players and take preventive measures to reduce the overuse of the external rotators.

Methodological Limitations and Suggestions for Future Research

Some methodological limitations of our study need to be considered when interpreting our results. First, all the differences in FPI observed between the three subject groups were not significant, so no firm conclusions can be drawn about the influence of a particular sport on foot posture. Secondly, the small sample size hinders statistical power and thus reduces the sensitivity for detecting small changes in the mean values or weak correlations between the measured parameters. In future studies, larger and more representative samples should be drawn from different sports clubs. To increase the sensitivity for detecting correlations between hip ROM and foot posture, the sample should also include participants with pathological foot posture. Third, only goniometric measurements of the passive rotational ROM with the hip extended were used, which may not be fully representative of functional hip motion. In future studies, active ROM measurements should be used in both seated (with flexed hip) and prone positions and, if possible, combined with more complex biomechanical analyses of the hip, knee, ankle, and foot ROM during sport-specific activities. In addition, information on the use of orthotic insoles by athletes to correct their feet should be systematically collected and used as a covariate in future studies, as their influence on foot posture may be significant.

CONCLUSIONS

No significant differences were found in the Foot Posture Index between handball players, soccer players, and non-athletes. Handball and soccer players show a tendency toward less pronated feet compared to non-athletes, but the differences are not significant and the mean FPI values are still within the range of normal foot posture. The soccer players had significantly less hip internal rotation than the other two groups, which was also weakly but significantly and positively correlated with their FPI values. These results may serve as a guide for future studies of subgroups of athletes with pronounced postural defects of the feet. As it has previously been shown that a limited internal rotation of the hip joint also increases the risk of hip adductor injuries, further research is needed in this regard. Future studies should also use measurements of the ac-

tive hip ROM or even more complex biomechanical analyses of the hip, knee, ankle, and foot ROM during sport-specific movement patterns.

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Review article
received: 2023-04-20

DOI: https://doi.org/10.35469/ak.2023.389
UDC: 796.015:616.12-008.33-053.9

THE INFLUENCE OF PHYSICAL ACTIVITY ON THE ARTERIAL BLOOD PRESSURE OF THE ELDERLY: A SYSTEMATIC REVIEW

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ABSTRACT

***Purpose**: The aim of this review was to determine the influence of physical activity on the arterial blood pressure of the elderly through a review of previous research.*

***Methods**: The search was performed on the Web of Science, Google Scholar and PubMed databases. The first search identified 1112 articles. In the initial assessment carried out in accordance with the inclusion and exclusion criteria, 15 articles were found suitable and were included in the study, while 1097 studies were excluded. The search was limited to articles published in period of 2002–2022.*

***Results**: After the applied exercise programs and evaluation at the final measurements, the mean values of systolic blood pressure, on the total sample, were 131 mmHg, while the values of diastolic blood pressure were 77 mmHg, which indicates that physical activity (regardless of whether swimming, walking, yoga, resistance training, high interval training, Tai Chi) have a positive effect on the arterial blood pressure of the elderly.*

***Conclusion**: All studies, except one, showed a positive influence of physical activity on the arterial blood pressure of elderly people. In this regard, it can be concluded that physical activity, regardless of the type of activity, has a positive effect on the arterial blood pressure of the elderly, in the form of a reduction in blood pressure values.*

***Keywords**: physical activity, arterial blood presure, elderly.*

VPLIV TELESNE DEJAVNOSTI NA ARTERIJSKI KRVNI TLAK PRI STAREJŠIH OSEBAH: SISTEMATIČNI PREGLED

IZVLEČEK

***Namen**: Namen te analize je bil s pregledom dosedanjih raziskav ugotoviti vpliv telesne dejavnosti na arterijski krvni tlak pri starejših osebah.*

***Metode**: Iskanje je potekalo v podatkovnih zbirkah Web of Science, Google Scholar in PubMed. Pri prvem iskanju je bilo opredeljenih 1112 člankov. Pri začetni presoji, opravljeni v skladu z merili za vključitev in izključitev, se je 15 člankov izkazalo za primerne in so bili vključeni v študijo, medtem ko je bilo 1097 študij izključenih. Iskanje je bilo omejeno na članke, objavljene v obdobju 2002–2022.*

***Rezultati**: Po izvedenih vadbenih programih in oceni ob končnih meritvah so bile povprečne vrednosti SKT na celotnem vzorcu 131 mmHg, vrednosti DKT pa 77 mmHg, kar kaže, da imajo telesne dejavnosti (ne glede na to, ali gre za plavanje, hojo, jogo, vadbo vzdržljivosti, visoko intervalni trening, tai chi) pozitiven učinek na arterijski krvni tlak starejših oseb.*

***Sklep**: Vse študije, razen ene, so pokazale pozitiven vpliv telesne dejavnosti na arterijski krvni tlak starejših oseb. V zvezi s tem lahko sklepamo, da ima telesna dejavnost, ne glede na vrsto dejavnosti, pozitiven učinek na arterijski krvni tlak starejših, in sicer v obliki zmanjšanja vrednosti krvnega tlaka.*

***Ključne besede**: telesna dejavnost, arterijski krvni tlak, starejše osebe.*

INTRODUCTION

Aging is a natural process of life characterized by specific physical, psychological, and social changes (Hamidizadeh, Ahmadi & Fallahi, 2004). In addition, aging refers to irreversible degenerative changes that are generally progressive, in which the physical condition of an older individual deteriorates, along with their ability and motivation to engage in physical activity (Fiori, Smith & Antonucci, 2007). As a result, practically all organs in most elderly people experience some degree of degradation/atrophy in their morphological forms or in the tasks they perform in the body. As a result, various chronic diseases appear in older individuals, including cardiovascular diseases such as hypertension, coronary artery diseases, and skeletal diseases such as arthritis, osteoporosis, and cancer (Hamidizadeh et al., 2004).

Arterial blood pressure (BP) is an important indicator of cardiovascular health, and hypertension (high blood pressure) is a major risk factor for the development of cardiovascular disease in the elderly (Chobanian et al., 2003). The risk of hypertension tends to be greater in elderly, and it is one of the diseases that can be treated. Physical activity is a well-established lifestyle factor that can lower blood pressure levels and reduce the risk of hypertension in older adults (Cornelissen & Smart, 2013; Pescatello, MacDonald, Lamberti, & Johnson, 2015). However, the relationship between physical activity levels and blood pressure in older adults is complex, and the optimal amount and intensity of physical activity required to achieve blood pressure reduction is still unclear (Pescatello et al., 2015). In addition, other factors such as age, gender, body mass index, and comorbidities such as diabetes and chronic kidney disease may influence the relationship between physical activity levels and blood pressure in the elderly. Therefore, it is important to investigate the effect of physical activity on blood pressure in the elderly while controlling for these confounding variables.

Several studies have examined the impact of physical activity levels on BP in older adults, with some showing a significant association between higher physical activity levels and lower BP (Pescatello et al., 2015), while others have reported mixed or non-significant findings (Cornelissen & Smart, 2013; Graca et al., 2022). Moreover, some studies suggest that a sedentary lifestyle increases the risk of hypertension, while increased physical activity at work or leisure is associated with lower blood pressure values (Kokkinos, Papademetriou, 2000). The effect of aerobic exercise on hypertension was mainly tested in long-term exercise programs (at least three months) with high intensity and a large number of sessions per week (5 days per week). In a study by Moraes et al. (2012), the intervention group's mean systolic and diastolic blood pressure decreased

by 3 mmHg and 1 mmHg, respectively, after three days of aerobic exercise per week for three months, but the control group's mean blood pressure showed no significant change. The short-term program had no effect on lowering systolic blood pressure, but it did lower diastolic blood pressure, according to a study by Tabara et al. (2007) comparing aerobic short-term and long-term exercise programs with mild and moderate intensities on cardiovascular indicators of older adults. Mean systolic and diastolic blood pressure decreased throughout time, from 136 mmHg to 129 mmHg, and 87 mmHg to 83 mmHg, respectively.

Based on a review of the literature, we can conclude that the previous studies are not sufficiently balanced and that there are many dilemmas about the influence of physical activity on the arterial pressure of the elderly. This study investigated the effects of multiple types of physical activity on arterial blood pressure in the elderly. Knowing the effect of physical activity on the arterial blood pressure of the elderly, this paper contributes by sublimating the evidence and showing the effect of physical activity on blood pressure. In this context, we assume that individuals who had higher level of physical acitivity would have preferable, that is lower SBP and DBP, BP values. Although the work is not unique, it represents evidence-based evidence of the importance of physical activity for blood pressure. Also, most systematic reviews focus on the study of one type of physical activity, while showing the importance of multiple types of physical activity gives importance in planning physical activity programs in order to regulate blood pressure, where it is possible to make the program more flexible.

Therefore, the aim of this study was to determine the influence of physical activity on the arterial blood pressure of the elderly through a review of previous research.

METHODS

This study was designed using the systematic review technique. Research data was collected considering the inclusion and exclusion criteria of the studies published, as a result of the search made by using the keywords "physical activity, artirial blood presure, eldery" in English. The search was performed on the Web of Science, Google Scholar and PubMed databases. In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, a systematic review of the available literature was undertaken (Moher, Liberati, Tetzlaff & Altman, 2009) (Figure 1.). The first search identified 1112 articles. In the initial assessment carried out in accordance with the inclusion and exclusion criteria, 15 articles were found to be suitable and

were included in the study, while 1097 studies were excluded. In order for a study to be included in the analysis, it had to meet the following criteria: year of publication (2002–2022), participants were eldery people (≥50 yrs), also the studies that were included in this review had to be based on the influence of physical activity on the arterial blood pressure of the elderly. References from all papers were reviewed in order to find more studies that dealt with topics that were of interest and related to our review paper.

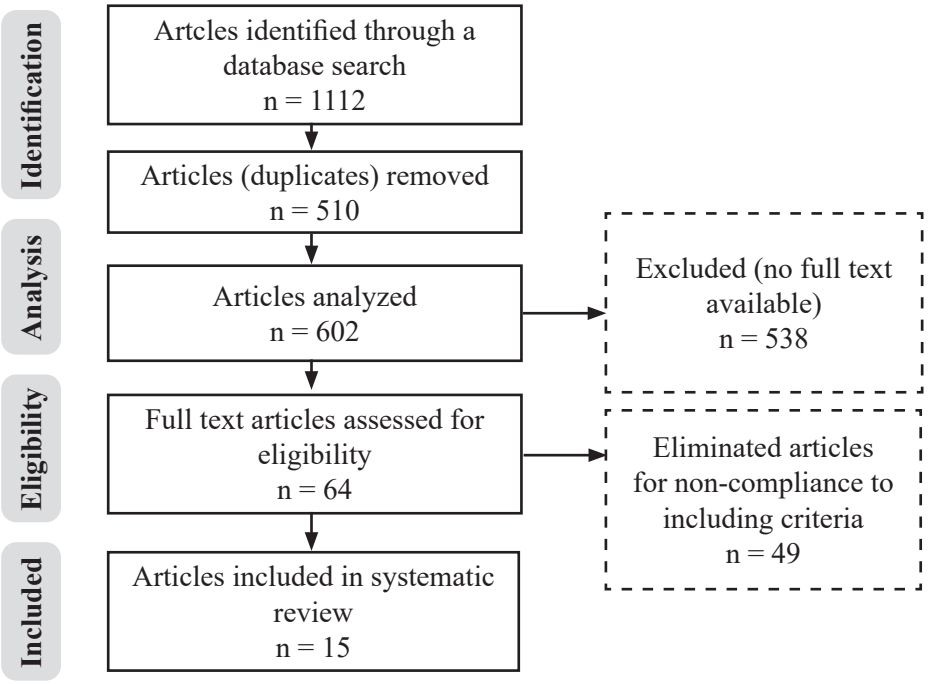

Figure 1. PRISMA flow chart of article selection process

RESULTS

In this part, 15 original scientific studies are presented on the topic of the influence of physical activity on the arterial blood pressure of the elderly in Table 1.

Table 1. Systematic review of the studies

Authors	Participants	Experimental program	Mean SBP (Before intervention)	Mean DBP (After intervention)	Results
Tabara et al. (2007)	n = 139 2 groups Age 67±6	Mild to moderate aerobic exercise for 30 minutes 2/week for 6 months	136 mmHg 75 mmHg	129 mmHg 70 mmHg	Both SBP and DBP were significantly reduced
Kawasaki et al. (2011)	n = 35 2 groups Age 57–73	6-month exercise program (swimming) 2/week	136 mmHg 81 mmHg	132 mmHg 77 mmHg	The exercise program significantly improved SBP and DBP, as did lipid and glucose metabolism
Pitsavos et al. (2011)	n = 42 2 groups Age 53 ± 7	Aerobic exercise program for 16 weeks, 3/week, with 60 to 80 max. heart rate	131 mmHg 83 mmHg	119 mmHg 76 mmHg	This study showed a positive effect of regular exercise on SBP and DBP
Habib et al. (2014)	n = 92 2 groups Age 65–75	4-week period of walking, 3/ week, each time for 20–30 minutes	149 mmHg 94 mmHg	144 mmHg 85 mmHg	The findings showed that walking is effective in reducing blood pressure in the elderly
Miura et al. (2015)	n = 200 2 groups Age 60–88	12-week program (90 minutes 2/week), 6–8 resistance exercises, circuit training and chair exercises for the lower body	150 mmHg 84 mmHg	145 mmHg 80 mmHg	Both groups had reductions in SBP and DBK (group doing circuit training and group doing lower body chair exercises)
Patil et al.(2015)	n = 60 2 groups Age ≥60	Yoga training and brisk walking with stretching exercises 1 hour in the morning 6/week for 12 weeks	146 mmHg 74 mmHg	133 mmHg 73 mmHg	Yoga was more effective than brisk walking in reducing SBP and DBP

Authors	Participants	Experimental program	Mean SBP (Before intervention)	Mean DBP (After intervention)	Results
Ardakani et al. (2018)	n = 24 2 groups Age 67.37	8 weeks of resistance training, 3/week with 40–65% intensity + one max. repetition	143 mmHg 72 mmHg	138mmHg 70mmHg	Resistance training for 8 weeks reduced SBP to a greater extent than DBP
Wong et al. (2018)	n = 100 2 groups Age~74	Swimming 3–4/week for a period of 20 weeks	147 mmHg 92 mmHg	143mmHg 86 mmHg	Swimming led to a decrease in blood pressure while increasing strength and aerobic capacity in women
Amooali et al. (2019)	n = 40 2 groups Age 50–70	Aerobic exercises performed 3 times a week for 12 weeks	145 mmHg 86 mmHg	140 mmHg 81 mmHg	Aerobic exercise for 12 weeks was effective in reducing SBP and DBP
Ruangthai & Phoemsapthawee (2019)	n = 54 3 groups Age 67±5.8	Supervised exercise training (1-hour sessions, 3 times a week for 12 weeks), (strength and endurance training + combined)	146 mmHg 84 mmHg	141mmHg 76 mmHg	Both types of training, as well as the combination of the two, led to a decrease in SBP and DBP
Herrod et al. (2020)	n = 48 4 groups Age 71.0	HIIT on a cycle ergometer; isometric handgrip training (IHG); unilateral, upper limb remote ischemic preconditioning (RIPC) or non intervention control	HIIT 142 mmHg 85 mmHg IHG 139 mmHg 83 mmHg	HIIT 131 mmHg 82 mmHg IHG 131 mmHg 75 mmHg	6 weeks of fully supervised HIIT or IHG can reduce the resting SBP of older adults by an average of 9 mmHg

Authors	Participants	Experimental program	Mean SBP (Before intervention)	Mean DBP (After intervention)	Results
Choi et al. (2020)	n = 27 2 groups Age 72–77	Elastic band exercises (EBE) for 60 min, 3/week for 3 months. The exercises consisted of incremental resistance and aerobic exercises.	126 mmHg 78 mmHg	121 mmHg 75 mmHg	Resting SBP and DBP were significantly reduced by ~5.0 mmHg after the 12-week EBE program
Iellamo et al. (2021)	n = 36 3 groups Age ≥ 60	Aerobic continuous exercise (ACE), HIIT, and combined (aerobic and resistance) exercise (CE)	ACE 121 mmHg 81 mmHg CE 121 mmHg 82 mmHg	ACE 115 mmHg 78 mmHg CE 114 mmHg 78 mmHg	SBP lowering significant in the ACE and CE groups but not in the HIIE group. In all groups, DBP decreased to a similar level, although not significantly.
Wen & Su (2021)	n = 66 2 groups Age 50–75	60 minutes of simplified Tai Chi (STC) 3/week for 6 weeks or 60 min of Wu-style Tai Chi (WTC) 3/ week for 6 weeks	STC 134 mmHg 80 mmHg WTC 136 mmHg 80 mmHg	STC 124 mmHg 77 mmHg WTC 123 mmHg 76 mmHg	Results showed that compared with simplified Tai Chi, Wu-style Tai Chi had a better effect on BP in the elderly −5.80 (mmHg)
Graça et al. (2022)	n = 32 2 groups Age 55–72	Resistance training followed by HIIT or vice versa (8 weeks)	119 mmHg 80 mmHg	114 mmHg 74 mmHg	Blood pressure did not change significantly following the intervention for either group

Legend: Mean BP – arterial blood pressure before the exercise program (mean values); Mean BP – arterial blood pressure after the exercise program (mean values); n – number of participants; SBP – systolic blood pressure; DBP – diastolic blood pressure.

DISSCUSION

Hypertension is a serious public health challenge worldwide, being quantitatively the major risk factor for premature cardiovascular disease (Angeli, Reboldi & Verdecchia, 2013). If the underlying problem is not prevented or treated, many patients with hypertension die from hypertension-related diseases. Therefore, the aim of this review was to determine the influence of physical activity on the arterial blood pressure of the elderly, regardless of gender, through a review of previous research.

In the selected studies, there was usually one group that had to fulfill the conditions (the elderly population) in order to participate in the study. The number of participants varied from study to study, the smallest number of participants was included in our study (Ardakani, Qassemian, Koushki, Shakour & Mehrez, 2018) had a sample of only 24 elderly people, and the largest number (Miura, Takahashi, Maki, & Sugino, 2015) as many as 200 elderly people. The total number of participants in the present study amounted to 995 elderly people between the ages of 50 and 88.

Data from all the studies presented show that the mean values of systolic blood pressure (SBP) before exercise, in the total sample, were 138 mmHg, while the mean values of diastolic blood pressure (DBP) before exercise were 82 mmHg. After the exercise programs and evaluation at the final measurements, the mean values of SBP, on the total sample, were 131 mmHg, while the values of DBP were 77 mmHg, which indicates that physical activities (regardless of whether swimming, walking, yoga, resistance training, high interval training or Tai Chi) have a positive effect on the arterial blood pressure of the elderly.

When it comes to physical activity, people who exercised more frequently and for a longer period of time had better improvements in the mean values of arterial blood pressure compared to people who did not exercise, i.e. sedentary individuals from control groups in the presented studies (Habib, Fariba, Farideh, Navideh & Saeed, 2014; Kawasaki, Sullivan, Ozoe, Higaki & Kawasaki, 2011; Wong et al., 2019; Ardakani et al., 2018; Pitsavos et al., 2011; Patil, Aithala & Das, 2015; Amooali, Daryanoosh, Baigi & Mohamadi, 2019). It is clear that all forms of physical activity have a positive effect on arterial blood pressure, with significant improvements observed after the swimming program (Kawasaki et al., 2011; Wong et al., 2019), walking / brisk walking program (Amooali et al., 2019; Pitsavos et al., 2011; Patil et al., 2015; Habib et al., 2014; Tabara et al., 2007; Iellamo et al., 2021), and resistance training (Ruangthai & Phoemsapthawee 2019; Miura et al., 2015; Ardakani et al., 2018; Choi, Hurr &

Kim, 2020), with the same positive effects being observed in the study by Wen & Su (2021) that implemented simplified Tai Chi and Wu-style Tai Chi and Patil et al. (2015) who implemented yoga sessions (Patil et al., 2015). Only one study did not find significant changes in SBP or DBP after intervention (Graça et al., 2022), in which they implemented resistance traning and high-intensity interval training for 8 weeks. A total of 14 out of 15 studies shown in the table showed positive results of physical activity on arterial blood pressure and in this connection we can conclude that physical activity, in general, has a positive effect on the arterial blood pressure of the elderly.

CONCLUSION

Physical activity (regardless of whether swimming, walking, yoga, resistance training, high interval training or Tai Chi) has a positive effect on the arterial blood pressure of the elderly.

With the exception of one study, all the other studies reviewed demonstrated a beneficial impact of physical activity on the arterial blood pressure of elderly individuals. In light of this, it can be concluded that physical activity, regardless of type of activity, yields favorable results by lowering blood pressure values in the elderly population.

Limitations of the study

This study has potential limitations. The study's stringent inclusion and exclusion criteria may have limited the amount of literature gathered. Additionally, the heterogenity of studies included in this systematic review indisposed us of performing meta-analysis. Also, there are numerous internal and external factors, such as gender, age, level of metabolical health, stress etc., that can affect BP values, but the analyzed studies did not take into account all these variables.

Acknowledgement

All authors equally contributed in preparation of this manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

Future research

For future research, it is recommended to use a larger number of studies included in systematic review. Also, it is desirable to include studies based on only one type of physical activity.

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Review article
received: 2023-12-07
DOI: https://doi.org/10.35469/ak.2023.425
UDC: 796.015:616.891.4

EFFECTS OF GRADED EXERCISE THERAPY AND MEDICAL CARE ON CHRONIC FATIGUE SYNDROME

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ABSTRACT

Purpose: *Chronic Fatigue Syndrome (CFS) / Myalgic Encephalomyelitis (ME) is a complex condition with debilitating symptoms that significantly impact individuals, particularly those in the working population. This study aims to investigate the effectiveness of Graded Exercise Therapy (GET) and Cognitive Behavioral Therapy (CBT) along with additional methods such as Graded Exercise Self-help (GES), Adaptive Pacing Therapy (APT), and Specialist Medical Care (SMC), in managing Chronic Fatigue Syndrome (CFS) / Myalgic Encephalomyelitis (ME) among the working population.*

Methods: *A systematic analysis of five randomized controlled trials conducted between 2013 and 2023, encompassing GET, CBT, APT, SMC, and GES was performed using PubMed.*

Results: *The selected studies consistently demonstrate that GET positively impacts physical functioning and reduces fatigue levels in working individuals with CFS. Additionally, CBT proves valuable, emphasizing the importance of addressing the mental aspects of CFS in occupational contexts.*

Conclusion: *This review underscores the need for further research, advocating for direct assessment methods like biomarkers to enhance our understanding of CFS and improve treatment outcomes. These insights are crucial for healthcare practitioners, researchers, and policymakers navigating the complexities of CFS within the workplace. Emphasizing the integration of psychological interventions with physical thera-*

pies is essential for a comprehensive approach to managing CFS among the working population.

Keywords: *Chronic Fatigue Syndrome / Myalgic Encephalomyelitis, CFS/ME, graded exercise therapy, cognitive behavioral therapy, adaptive pacing therapy, specialist medical care, working population.*

UČINKI STOPNJEVANE VADBENE TERAPIJE IN ZDRAVSTVENE OSKRBE NA SINDROM KRONIČNE UTRUJENOSTI

IZVLEČEK

Namen: *Sindrom kronične utrujenosti (CFS)/mialgični encefalomielitis (ME) je zapletena bolezen z izčrpavajočimi simptomi, ki močno vplivajo na posameznike, zlasti na delovno aktivno prebivalstvo. Namen te študije je raziskati učinkovitost stopnjevane vadbene terapije (GET) in kognitivno-vedenjske terapije (CBT) skupaj z dodatnimi metodami, kot so stopnjevana vadba za samopomoč (GES), terapija s prilagojenim tempom (APT) in specialistična zdravstvena oskrba (SMC), pri obvladovanju sindroma kronične utrujenosti (CFS)/mialgičnega encefalomielitisa (ME) med delovno populacijo.*

Metode: *Sistematična analiza petih randomiziranih nadzorovanih raziskav, opravljenih med letoma 2013 in 2023, ki vključujejo GET, CBT, APT, SMC in GES, je bila opravljena s pomočjo PubMeda.*

Rezultati: *Izbrane študije dosledno dokazujejo, da GET pozitivno vpliva na telesno delovanje in zmanjšuje stopnjo utrujenosti pri zaposlenih posameznikih s CFS. Poleg tega se CBT izkaže za koristno, kar poudarja pomen obravnave duševnih vidikov CFS v poklicnem kontekstu.*

Sklep: *V pregledu je poudarjena potreba po nadaljnjih raziskavah, pri čemer se zagovarja neposredne metode ocenjevanja, kot so biomarkerji, da bi izboljšali naše razumevanje CFS in izboljšali rezultate zdravljenja. Ta spoznanja so ključna za zdravstvene delavce, raziskovalce in oblikovalce politik, ki se spopadajo z zapletenostjo CFS na delovnem mestu. Poudarjanje vključevanja psiholoških intervencij v vadbene terapije je bistvenega pomena za celovit pristop k obvladovanju CFS med delovno aktivnim prebivalstvom.*

Ključne besede: *sindrom kronične utrujenosti/mialgični encefalomielitis, CFS/ME, stopnjevana vadbena terapija, kognitivno-vedenjska terapija, terapija s prilagojenim tempom, specialistična zdravstvena oskrba, delovna populacija.*

INTRODUCTION

Chronic Fatigue Syndrome (CFS) / *Myalgic Encephalomyelitis* (ME) is a medical condition characterized by profound fatigue and a range of associated symptoms, such as musculoskeletal pain, sleep disorders, cognitive impairments including concentration and memory deficits, headaches and a low tolerance for physical activity affecting individuals for six months or more (Prins, van der Meer, & Bleijenberg, 2006). Despite its significant impact, effective medical responses are hindered by the lack of standardized diagnostic tests and a comprehensive understanding of its pathophysiology (Sandler & Lloyd, 2020). The etiology of CFS remains elusive, encompassing various theories related to viral infections, immune imbalances, hormonal factors, genetic predispositions, and psychological stress (Sandler & Lloyd, 2020). Recent epidemiological studies have highlighted a high prevalence of CFS, particularly among adults (Johnston, Brenu, Staines, & Marshall-Gradisnik, 2013) and predominantly affecting women (Faro et al., 2016). While there is no universal tool for assessing CFS patients comprehensively (Bergner et al., 1976), specific questionnaires, such as the *Chalder Fatigue Questionnaire* (CFQ), are frequently used to assess the severity of symptomatic fatigue (Chalder et al., 1993), which has been shown to reliably discriminate between clinical and nonclinical conditions (Cella & Chalder, 2010), and the *Multidimensional Fatigue Inventory* (MFI-20) for comprehensive fatigue assessment (Shahid, Wilkinson, Marcu, & Shapiro, 2012). Additionally, various interventions have been proposed for managing CFS symptoms, including *Cognitive Behavioral Therapy* – CBT, *Graded Exercise Therapy* – GET, *Adaptive Pacing Therapy* – APT, *Specialist Medical Care* – SMC, and *Graded Exercise Self-help* – GES. CBT addresses the cognitive, behavioral, and symptomatic aspects of CFS, guiding participants to develop coping strategies (White, Goldsmith, Johnson, Chalder, & Sharpe, 2013). GET gradually increases physical activity to improve fitness in CFS/ME treatment (Sharpe et al., 2015). APT manages energy through activity assessment and pacing (Walwyn et al., 2013), while SMC offers explanations, guidance, and medical recommendations (Clark et al., 2017) and GES involves a six-step exercise program (Clark et al., 2017). Given the significant impact of CFS/ME on the working population (Valdez et al., 2019), there is a critical need to analyze existing research and interventions specifically designed for this condition. Therefore, the aim of this article is to provide a concise yet comprehensive examination of the current research and interventions aimed at managing CFS/ME symptoms within the working population, highlighting the impor-

tance of addressing the unique challenges faced by working individuals with this condition.

METHODS

The research methodology is based on a descriptive approach, involving the analysis of previous studies conducted between 2013 and 2023 using the PubMed domain using the words "CFS" OR "GET" OR "CBT" "APT" OR "SMC" OR "working population". The search specifically focused on randomized controlled trials and the literature review concentrated on studies incorporating the working population as a subject due to their increased vulnerability to this condition. The inclusion criteria were that participants involved in the study must have a diagnosed with CFS, belong to the working population, and the intervention in the treatment or prevention of CFS consisted of GET, CBT, APT, SMC, or GES. Additionally, the articles had to be written in the English language and the full text must be accessible. The exclusion criteria comprised studies addressing other forms of fatigue, those that did not specifically apply to research on the influence of physical activity on CFS, studies involving adolescents, and those assessing physical fitness after the administration of specific supplementation or medication.

RESULTS

The following results were obtained through the research of the PubMed database, based on keyword search and their combination, adhering to the inclusive and exclusive criteria. A total of 61 articles were identified through data research, from which 19 abstracts were reviewed. All the identified articles were read in full to assess eligibility and quality. In the end, a total of five articles were included in the review. An overview of the search and selection methodology procedure is described in Figure 1 through a Prisma diagram.

Based on the results presented in *Table 1* regarding the use of different programs in the treatment of CFS, the outcomes for patients receiving GET or GES treatment combined with CBT indicated a reduction in fatigue, with patients reporting an improvement in physical and cognitive functioning. SMC and APT showed improved outcomes in long-term follow-ups.

In the study conducted by White et al. (2013), commonly known as the PACE study (Table 1), the effectiveness of different treatments for CFS in achieving

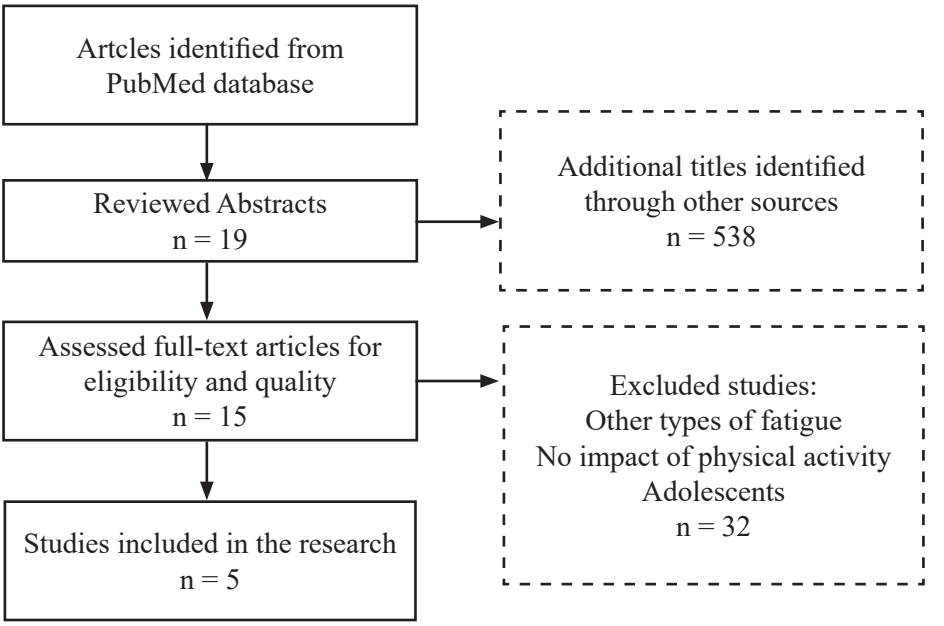

Figure 1. An overview of the search and selection methodology procedure.

recovery was compared in a sample of 641 participants over 52 weeks. The average age of the participants was 38 years, with 77% being female. The study included four treatment groups: cognitive-behavioral therapy (CBT), graded exercise therapy (GET), and adaptive pacing therapy (APT), combined with specialist medical care (SMC), as well as SMC alone. Physicians specializing in CFS were responsible for treating participants in the SMC program. Occupational therapists oversaw SMC and APT, clinical psychologists SMC and CBT, and physiotherapists SMC and GET. The primary goal was to determine how many participants in each treatment group achieved complete recovery based on different criteria. Specialist doctors explained the symptoms of the syndrome to the patients and ways to manage their condition, prescribing medications to alleviate symptoms such as pain and insomnia. APT involved carefully matching activity levels to the energy levels of the participants. CBT examined the connection between thoughts and behaviors, encouraging participants to try new ways to cope with their condition. GET gradually increased the volume and intensity of physical activity to improve fitness and reacquaint the body with activity. The method of self-assessment using the standardized CFQ

Table 1. Articles Included in the Analysis of the Impact of GET and CBT in the Treatment of CFS.

Study	**Journal**	**Study type**		
1. White et al., 2013	Psychological Medicine	RCT		
2. Sharpe et al. 2015	Lancet Psychiatry	Pre-post trial		
3. Clark et al., 2017	The Lancet	RCT		
4. Wilshire et al., 2018	BMC Psychology	RCT		
5. Clark et al., 2021	Journal of Psychosomatic Research	Pre-post trial		
↓ Sequence number	Interventions			
1. CBT, GET, SMC, APT				
2. CBT, GET, SMC, APT				
3. GES, SMC				
4. CBT, GET				
5. GES, SMC				
Study sequence number →	1	2	3	4	5
n	641	641	211	641	211
Duration	52 weeks	2 years	12 weeks	52 weeks	12 months
Results	↓ fatigue, ↑ physical and cognitive functioning	↓ fatigue, ↑ physical and cognitive functioning	↓ fatigue, ↑ physical and cognitive functioning	↓ fatigue, ↑ physical and cognitive functioning	↓ fatigue, ↑ physical and cognitive functioning, ↑ overall health

Legend: n-number of participants; ↓- decrease; ↑-increase; SMC – Specialist Medical Care; CBT – Cognitive Behavioral Therapy; GET – Graded Exercise Therapy; APT – Adaptive Pacing Therapy, GES – Graded Exercise Self-help

questionnaire was used to measure the participants' fatigue levels, and the SF-36 physical fitness assessment scale was used to assess physical and cognitive functionality. The study found the following percentages of participants who met the recovery criteria: CBT: 22%, GET: 22%, APT: 8%, and SMC alone: 7%. When comparing CBT and GET with APT and SMC alone, the chances of achieving recovery were significantly higher for CBT and GET.

The next study conducted by Sharpe et al. (2015), a follow-up investigation of the effects of the previously mentioned PACE study was conducted at least 2 years after randomization (Table 1). The aim was to assess additional treatments that participants received after the study and explore whether there were long-term effects in the context of recovery within and between the original groups exposed to different CFS treatments initially included in the PACE study. Of the 641 participants involved in the original PACE study, 75% of them returned the long-term follow-up questionnaire. Additional treatment had been received by 44% of the participants, with those originally assigned only SMC or APT, as opposed to GET or CBT, being more inclined to seek additional treatment. Improvement in terms of reduced fatigue and better physical and cognitive functionality reported by participants originally assigned CBT or GET methods was sustained in the long-term follow-up compared to one year. Participants initially assigned SMC or APT methods showed improvement in long-term follow-up compared to one year in the context of reduced fatigue and improved physical functionality. To measure the participants' fatigue levels, the method of self-assessment using the standardized CFQ questionnaire was again employed, and the SF-36 physical fitness assessment scale was used to assess physical functionality.

In the study by Clark et al. (2017), the researchers conducted a study called GETSET to investigate the impact of SMC compared to SMC with the addition of the modified Graded Exercise Self-help (GES) method, described in a self-help manual outlining a six-step graded exercise therapy, with an expected duration of approximately 12 weeks. Of the total 211 participants (adults aged 18 and above), 107 were assigned to the GES group, and 104 to the control group. The study aimed to compare the effects of the GES method combined with SMC versus SMC alone in the treatment of chronic fatigue syndrome, hypothesizing that the combined method would yield better results in terms of reducing fatigue and improving physical functionality. With the GES manual, participants had the option to conduct up to four guided sessions with a physiotherapist over 8 weeks, totaling 90 minutes. After 12 weeks, compared to the control group, 34% of the GES group showed 8 points of improvement on the SF-36 physical fitness assessment scale and 3 points of

improvement on the CFQ questionnaire, compared to a 14% improvement in the control group.

In study number 4 (Table 1), the authors Wilshire et al. (2018) conducted a reanalysis of the previously mentioned PACE study (White et al., 2013), primarily focusing on the effects of the GET and CBT methods. They noted that the original authors had not consistently adhered to the procedures outlined in the published protocol, and it is unclear whether the conclusions drawn are entirely justified by the evidence, suggesting that the impact of the applied methods in CFS therapy is limited to self-assessment. After the reanalysis of the self-assessment questionnaire results, the GET group had better ratings for physical function compared to the control group but not in fatigue self-assessment, while the CBT group showed better ratings in self-assessment of fatigue but not in physical function.

In a study conducted by Clark, McCrone, Pesola, Vergara-Williamson, and White (2021), the long-term effects of the GETSET research in the treatment of CFS were investigated. The aim of this study was to examine the effects of the GES study compared to SMC alone in the context of improved physical functioning and reduced fatigue, with an assessment of the long-term clinical and economic outcomes. Primary outcomes were evaluated through the CFQ questionnaire and SF-36 survey, with questionnaires mailed 12 months after the completion of the GETSET study. In the study, 78% of the participants returned the questionnaires 15 months after the study's commencement, with previously recorded improvements following GES being sustained in the long-term follow-up but without additional improvement and no significant difference compared to the control group.

DISCUSSION

Based on the existing research presented in *Table 1*, the results indicate that the application of GET improves physical functioning and reduces the perception of fatigue more than SMC alone in adults diagnosed with CFS (Clark et al., 2017). It can be stated that the GET method has consistent evidence of benefits in the treatment of CFS, supported by a conducted meta-analysis showing moderate evidence of improved physical functionality and reduced fatigue severity (Smith et al., 2015). In clinical practice, GET precedes activities involving adaptation, which includes identifying the threshold beyond which the prolonged worsening of symptoms occurs. Subsequently, a 'pacing' approach to activities is implemented to maximize the utilization of limited energy reserves (Sandler

& Lloyd, 2020). Compared to passive controls (such as relaxation or flexibility exercises), GET reduces the fatigue levels at the end of treatment with moderate certainty (Larun, Brurberg, Odgaard-Jensen, & Price, 2019). The specific characteristics of the symptomatology of patients with CFS require a prompt adaptation of educational, healthcare, and social systems to prevent issues arising from the current systems (Nacul et al., 2011). In earlier studies, it is noted that the majority of individuals diagnosed with CFS/ME will experience or have already experienced periods when their symptoms relapse or worsen (Clark, 2009). Clark (2009) concluded that it is crucial to have a plan for coping with the return of the symptoms to preserve the progress that has been made and, above all, identifying the cause of the symptom recurrence is essential to reduce the likelihood of it happening again. The reviewed studies collectively contribute to our understanding of therapeutic interventions for CFS/ME within the working population. The PACE study (White et al., 2013) compared various treatments, revealing that CBT and GET increased the recovery chances significantly. The follow-up study (Sharpe et al., 2015) demonstrated sustained benefits in participants assigned CBT or GET, while those on SMC or APT also showed improvement. The GETSET study (Clark et al., 2017) introduced modified graded exercise self-help – GES alongside SMC, exhibiting superior outcomes compared to SMC alone. Wilshire et al.'s (2018) reanalysis criticized the PACE study's methodology, highlighting limitations in its conclusions. Clark et al.'s (2021) long-term investigation of GETSET showed sustained benefits but no additional improvement over SMC.

CONCLUSION

In this study, we underscore the importance of integrating psychological and physical interventions for comprehensive CFS management within the working population. The findings from the reviewed studies, encompassing a combination of CBT and GET, and either SMC or APT, emphasize the significance of personalized treatment approaches. The consistent positive outcomes of CBT and GET, maintaining their effectiveness in the long term, highlight the critical role of psychological interventions in effectively addressing CFS among the working population. Furthermore, the analysis of the available data and the recommended treatment for CFS/ME indicates that short-term changes can be expected, resulting in a temporary reduction in the sensation of fatigue and an improvement in physical and cognitive functioning (Wilshire et al., 2018). The studies reviewed also revealed a predominant reliance on indirect

measurement methods, primarily employing self-reported questionnaires. To address existing gaps, there is a noteworthy need for more research utilizing direct assessment methods, such as biomarkers, providing a direct measurement of physiological changes. Previous research (Maksoud, Magawa, Eaton-Fitch, Thapaliya, & Marshall-Gradisnik, 2023) identified potential blood-based biomarkers, encompassing genetic/epigenetic, immunological/mitochondrial/microbiome, endovascular/circulatory, neurological, ion channel, and physical dysfunction biomarkers. Notably, the use of lymphocytes as a model for investigating CFS/ME pathology is prominent among the immune system-based biomarkers (Maksoud et al., 2023). However, the heterogeneity shown in many of the included studies highlights the need for multidisciplinary research and standardized protocols to advance our understanding and management of CFS/ME. While numerous blood abnormalities show promise as potential biomarkers for CFS/ME, none can reliably differentiate individuals with CFS/ME from those with other health conditions or those in perfect health (Maksoud et al., 2023). The variability in findings across studies underscores the necessity for multidisciplinary research and standardized protocols. A continual overview and the transparent reporting of research methods are essential for developing a comprehensive understanding of CFS/ME and refining treatment strategies.

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TECHNICAL NOTES

Technical notes
received: 2023-10-30

DOI: https://doi.org/10.35469/ak.2023.419
UDC: 796.015.86:616-001

A GROWING ISSUE OF OVERUSE INJURIES IN YOUNG ATHLETES

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ABSTRACT

Over the past two decades, participation in professional sports among children and adolescents has surged despite the rising inactivity and obesity rates. Approximately 60 million young individuals in the USA are involved in organized sports. This increase has led to a concerning rise in overuse syndromes, which is becoming a primary concern in sports medicine.

Our review aims to examine common overuse syndromes in youth athletes and assess risk factors, pathophysiology, and preventive measures. Early sports specialization, societal pressures, and competitive demands lead to repetitive strain injuries. The young musculoskeletal system, though adaptable, is prone to injuries from intense training and insufficient recovery.

Prevention advocates against early sports specialization and promotes adequate rest. Diversifying sports, limiting training hours, and a robust support system are recommended to counteract the mental effects of intense specialization.

In summary, a holistic approach is needed to address overuse syndromes, emphasizing diversification, education, and a balanced approach to sports.

Keywords: *adolescent athletes, early sports specialization, overuse syndromes, preventive measures, psychological well-being.*

TECHNICAL NOTES, 157–173

NARAŠČAJOČA PROBLEMATIKA PREOBREMENITVENIH SINDROMOV PRI MLADIH ŠPORTNIKIH

IZVLEČEK

V zadnjih dveh desetletjih se je udejstvovanje otrok in mladostnikov v profesionalnem športu močno povečalo, kljub splošno naraščajočemu deležu neaktivnosti in debelosti. V ZDA se z organiziranim športom ukvarja približno 60 milijonov mladih posameznikov. To povzroča zaskrbljujoče povečanje preobremenitvenih sindromov, pomembne patologije v športni medicini.

V tem preglednem članku obravnavamo preobremenitvene sindrome pri mladih športnikih, dejavnike tveganja, patofiziologijo in preventivne ukrepe. Zgodnja usmeritev v športu, družbeni pritiski in tekmovalne norme vodijo do poškodb zaradi ponavljajočih se obremenitev. Mladi mišično-skeletni sistem je sicer prilagojen na zmerno aktivnost, hkrati pa nagnjen k poškodbam zaradi intenzivnega treninga in nezadostnega okrevanja.

Preventivni ukrepi strmijo k preprečevanju zgodnje specializacije v športu in spodbujajo ustrezen počitek. Za ohranjanje mentalnega zdravja se priporočajo raznovrstnost športov, omejitev števila ur treninga in izdelan sistem pomoči.

Za obravnavo preobremenitvenih sindromov je potreben celosten pristop, ki poudarja diverzifikacijo, izobraževanje in uravnotežen pristop k športu.

Ključne besede: *športnik adolescent, zgodnja usmeritev v športu, preobremenitveni sindromi, preventivni ukrepi, psihološko zdravje.*

INTRODUCTION

Despite the rising rates of inactivity and obesity, the number of children and adolescents participating in organized or recreational athletics has increased significantly during the last two decades. (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007) It is estimated that around 60 million children and adolescents in the USA participate in some organized sports activities. (DiFiori et al., 2014) Although there have been no similar studies on participation in sports in Europe, a recent study found increased participation among U8 – U14 for most sports. (Emmonds, Till, Weaving, Burton & Lara-Bercial, 2023) Since moderate sports activities positively affect physiological and psychological health, overly trained and improperly recovered adolescents are at risk of various overuse syndromes, which is a hot topic in sports medicine and orthopedic surgery. This study aims to provide a comprehensive overview of the overuse syndromes in adolescents, known risk factors, pathophysiology, and prevention techniques.

RISK FACTORS

Overuse syndromes in youth are becoming a growing issue due to a combination of societal, cultural, and technological factors. There are several key reasons that contribute to the increase in overuse syndromes among young individuals. (Shigematsu, Katoh, Suzuki, Nakata, & Sasai, 2022; van Poppel et al., 2021) Young and inexperienced athletes with lower fitness levels may be more susceptible, especially at the beginning of a training period. Poor technique may result in disproportionate stress on certain tissues, leading to fatigue, which may predispose people to overuse syndromes. (Brenner &Watson, 2024; Leppänen et al., 2017) Previous injuries, high body mass index, female sex, weekly hours in sports, and high-level competitions were found to be among the most substantial risk factors. (Shigematsu et al., 2022; van Poppel et al., 2021) Many young athletes are encouraged to specialize in a single sport from a very early age. Early sport specialization, specifically in sports with considerable biomechanical repetition, limits young people to a single set of activities that can lead to repetitive strain on specific muscle groups and joints that exceeds the healing capacity of the tissue, resulting in an increased risk of overuse injuries. (Brenner &Watson, 2024; Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007; Shigematsu et al., 2022;

Sweeney, Rodenberg, & MacDonald, 2020) It also prevents young athletes from developing advanced motor skills and diverse movement patterns. Studies have shown that participating in multiple sports activities correlates with fewer overuse syndromes in youth athletes. (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007; Popkin, Bayomy, & Ahmad, 2019; Puzzitiello, Rizzo, Garvey, Matzkin, & Salzler, 2021)

The youth musculoskeletal system is an immature complex of bones, muscles, tendons, and ligaments that undergoes rapid growth and allows athletes to participate in various sports activities. However, growth-related changes make it vulnerable to acute and chronic injuries if exposed to excessive stress. (Aicale, Tarantino, & Maffulli, 2018) Unfortunately, modern training methods often involve high-intensity training regimens that push young athletes to their limits. Additionally, inadequate rest and recovery time between similar training sessions and muscle exercise can prevent the body from healing properly.

There's also a lack of adequate education about the risks of overuse injuries and the importance of injury prevention strategies, like proper warm-up, cool-down, and strength training. The desire to excel and competitive pressures from parents, coaches, and peers can drive young athletes to push themselves beyond their limits. (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007)

PATHOPHYSIOLOGY

Traditionally, the absence of a single, identifiable traumatic episode has been used to define a causal element of overuse injury. An overuse injury involves microtraumatic damage to a bone, muscle, tendon, or ligament caused by repetitive stress that fails to heal or undergo the natural reparative process. (Aicale et al., 2018)

Apophysitis

Apophyses (also entheses), secondary ossification centers with tendon insertions, are vulnerable to strenuous forces applied through muscle contractions, causing repetitive microtraumatic lesions, inflammatory scar reactions, and ectopic ossifications. They are considered two to five times weaker than the surrounding structures, including the muscle-tendon complex, ligaments, and bones. (Kose, 2010) Inflexibility and bone spurts before muscle lengthen-

ing can both contribute to increased traction forces. (Yanagisawa et al., 2014) Apophysitis is known to have multifactorial origins, including growth spurts, genetic predispositions, and anatomic features. (Gudelis et al., 2022) Combined with repetitive overuse activities like running, jumping, and throwing, which exert traction loads on the entheses, an inflammatory and degenerative response in the apophyseal cartilage can subsequently result in an avulsion fracture. (Gudelis et al., 2022).

Tendinopathy

Overuse tendinopathy induces nociceptors and swelling in the afflicted tendon, weakening its load tolerance and function during limb exercise. (Abate et al., 2009; Rio et al., 2014) Most sports-related tendinopathies have well-defined degenerative histopathological lesions, which explains the chronicity of symptoms that typically occur in athletes with tendinopathies. (Aicale et al., 2018; Sharma & Maffulli, 2006) Although the precise sequence of the natural healing process in tendinopathic tendons remains obscure, a failed healing response results in the degeneration and proliferation of tenocytes, disruption of collagen fibers, and a subsequent increase in non-collagenous matrix. (Longo, Ronga, & Maffulli, 2009, Longo et al., 2007) Under chronic stress, such as diabetes mellitus or obesity, an acute inflammatory response is significantly altered, which is marked by the failed migration of inflammatory cells. Similarly, mechanical stress that results in chronic stress may also explain the development of tendinopathy. (Aicale et al., 2018) Although the data on its prevalence and incidence are scarce, it primarily affects female and male volleyball and basketball players. (Nutarelli, da Lodi, Cook, Deabate, & Filardo, 2023) However, it is more common in adults due to the fused apophyses, which are the weakest part of the osteotendinous junction in adolescents. (Benjamin et al., 2006; Nutarelli et al., 2023)

Stress Reactions and Juvenile Osteochondritis Dissecans

Stress reactions may be followed by insufficient bone healing, resulting in stress fractures. The bone's reaction to recurrent stress is enhanced osteoclastic activity over osteoblastic new bone formation, resulting in temporary bone weakening. (Fullem, 2015) Physiologically, the new periosteal formation is then stimulated. (Harrast & Colonno, 2010) If physical stress continues, osteo-

clastic activity may predominate, resulting in microfractures, and, ultimately, a real cortical break (stress fracture). (Chéron, Le Scanff, & Leboeuf-Yde, 2017) Various interrelated extrinsic and intrinsic factors contribute to an excessive load on bones. A primary risk factor is an increase in the frequency, duration, and intensity of training load. (Johanson, 1992) Hard training surfaces and shoes older than six months also contribute to less optimal shock absorption. Among the intrinsic factors, low bone mineral density (BMD), loss of muscle mass, and small calf girth are associated with a higher incidence of stress fractures. (Harrast & Colonno, 2010; Pohl, Mullineaux, Milner, Hamill, & Davis, 2008)

Repetitive microtrauma is also considered a significant cause of juvenile osteochondritis dissecans. (Pascual-Garrido, Moran, Green, & Cole, 2013) It weakens the subchondral bone, resulting in local necrosis and delamination, followed by an intraarticular loose body if untreated. It is a common cause of knee pain in adolescents, both athletes and non-athletes. (Kumar, Bhatnagar, & Lodhi, 2018) Although "ostochondritis" indicates the inflammatory process, histological results suggest no signs of inflammation. (Rothermich, Glaviano, Li, & Hart, 2015) However, the thorough etiology remains unclear. (Schulz & Chambers, 2013)

SPECIFIC CONDITIONS

Lower Extremity

Osgood-Schlatter and Sinding-Larsen-Johansson Disease

Traction apophysitis occurs on both sides of the patellar tendon. Osgood-Schlatter disease (OSD) affects the tibial tubercle, whereas Sinding-Larsen-Johansson disease (SLJD) is located under the inferior pole of the patella. The peak incidence for SLJD is at around 10 and 13 years, while OSD occurs at around 10 and 15 years when children undergo a growth spurt. (Patel & Villalobos, 2017; Yen, 2014) It is more common in athletes vs. non-athletes (21% vs. 4.5%, respectively). (de Lucena, dos Santos Gomes, & Guerra, 2011) Young volleyball and basketball players, jumpers, and runners are known to be at risk of apophysitis around the knee since these sports require repetitive jumping activity that exerts stress on the patellar ligament. (Itoh et al., 2018) In 30% of OSD, the disease presents bilaterally. (Circi, Atalay, & Beyzadeoglu, 2017) Diagnosis is usually clinical, with tenderness and swelling on either side of the

patellar insertion. Regarding OSD disease, conservative treatment is successful and symptoms typically disappear after the finish of growth. Given the benign nature of the disease, children are encouraged to continue with activities. (Circi et al., 2017) Conversely, SLJD disease requires more attention to stretch the hamstrings, quadriceps, and heel cord in combination with relative rest. (Valentino, Quiligotti, & Ruggirello, 2012) Symptoms can take up to 24 months to completely resolve, though pain usually doesn't persist after the fusion of apophysis. (Valentino et al., 2012)

Sever Disease

Sever disease or calcaneal apophysitis is a common cause of heel pain in youth athletes. (Ishikawa, 2005) It occurs at the insertion of the Achilles tendon into the calcaneus and is frequently worsened by running or jumping. (James, Williams, & Haines, 2013) Risk factors include a tight heel cord, running and jumping activities, and early sports specialization. (Elengard, Karlsson, & Silbernagel, 2010) It is common among young basketball, volleyball, and football players. (Martinelli et al., 2019) Diagnosis is clinical, with tenderness over the calcaneal insertion. Pain management is conservative and stretching plays a vital role. (James et al., 2013)

Patellofemoral Syndrome

This represents one of the most common causes of knee pain in adolescents. It includes peripatellar and retropatellar pain that is exacerbated by specific positions and activities. (Calmbach & Hutchens, 2003) While traction apophysitis more often affects boys, patellofemoral syndrome is more common among female athletes. (Vora, Tien, Parks, & Schon, 2006) The reported annual incidence of patellofemoral syndrome among adolescents ranges from 3% to 40%. (Callaghan & Selfe, 2007) It is a common complaint in the active population, particularly in adolescent athletes who participate in jumping, cutting, and pivoting sports. (Halabchi, Abolhasani, Mirshahi, & Alizadeh, 2017) Although the exact etiology remains unknown, muscle imbalance, patellar instability, tendinosis of the extensor apparatus, and chondral defects may be involved in the pathogenesis. (Pavone et al., 2022) Also, early sport specialization in female adolescents is associated with an increased risk of patellofemoral syndrome when compared with multisport athletes. (Hall, Barber Foss, Hewett,

& Myer, 2015) Patients complain of anterior knee pain that worsens with running, squatting, and prolonged sitting (theater sign). (Patel & Villalobos, 2017) Popping, catching, or the sensation of their knee giving way may be among the complaints. Examination reveals poor quadriceps and hamstring flexibility, tenderness around the patella with a positive grind test, and weak hip abductors. (Sweeney et al., 2020) Although the diagnosis is clinical, an x-ray may reveal biomechanical abnormalities such as patellar tilt and patella alta or baja. (Patel & Villalobos, 2017) Management is conservative with activity modification and an emphasis on the improvement of knee biomechanics. (Dixit, DiFiori, Burton, & Mines, 2007)

Iliotibial Band Syndrome

Especially common among runners and cyclists, iliotibial band syndrome (ITBS), also known as runner's knee, involves pain around the lateral femoral condyle as the ITB passes over. (Sweeney et al., 2020) Predisposing factors are lack of stretching with a tight ITB, varus knee deformity, and overpronation of the feet with an excessive internal rotation of the legs, which increase the friction around the lateral femoral condyle. Diagnosis is typically clinical and requires no additional imaging. Treatment consists of conservative modalities such as activity modification, stretching, and NSAIDs. (Patel & Villalobos, 2017) A steroid injection in refractory cases is rarely used in youth populations. (Ellis et al., 2010)

Osteochondritis Dissecans (OCD)

Also known as König's disease, it most commonly occurs in the lateral part of the medial femoral condyle. Between 10 and 13 years, boys are affected significantly more often than girls (4:1). (Launay, 2015) It is characterized by mechanical pain that is difficult to pinpoint. The diagnosis is radiological with an x-ray, though an MRI is also usually performed to define the extent of the subchondral bone edema. In advanced stages, loose bodies can be found intraarticularly, limiting the range of motion and locking the knee. Treatment usually involves avoiding sports activities for six months, whereas partial weight bearing is allowed if pain is absent. Lesions smaller than 2.5 cm^2 have the greatest potential to heal through conservative methods. (Launay, 2015) Surgical

methods, such as microfracturing or osteochondral fixation, are reserved for advanced cases when conservative treatment fails. (Kreuz et al., 2006)

Similarly, OCD often occurs in the posteromedial aspect of the talus. Both ischemic and microtraumatic factors are believed to be involved in the process of the disease. It is common among boys over ten who participate in court-based sports such as volleyball and handball. (Launay, 2015) The symptoms, diagnosis, and treatment are similar to König's disease.

Upper Extremity

Little Leaguer's Elbow

Baseball players are among the most at risk of medial epicondyle apophysitis, also known as little leaguer's elbow. Between 20 and 40 % of youth pitchers suffer from thrower's elbow. (Otoshi et al., 2017) High pitch counts in each game, pitching on many teams, coach-driven incentives to throw harder, the use of a radar gun to monitor speed, and not taking enough time off from the sport during the year are all risk factors. (Norton et al., 2019) The act of throwing produces traction force on the medial epicondyle physeal plate, which results in tenderness in the medial epicondyle. A specific provoking test is the "milking maneuver", performed with resisted flexion/pronation with valgus stress. (Norton et al., 2019) Usually, conservative treatment suffices. However, the most important is a gradual return to pitching when the patient is free of pain. In refractory cases, avoidance of throwing positions is advised for up to a year. (Norton et al., 2019) Immobilization and surgical fixation are considered in refractory cases and avulsion fractures. (Haws et al., 2018)

Stress Fractures

Stress fractures are common among runners and jumpers. Insufficient caloric intake and low vitamin D levels may predispose people to bony stress reactions. (Sonneville et al., 2012) They are caused by the mechanical overload of a cortical bone, with half of them occurring at the metaphyseal-diaphyseal part of the proximal tibia. (Valovich McLeod et al., 2011) Furthermore, the anatomic locations of stress fractures are associated with specific types of sports. (Fredericson, Jennings, Beaulieu, & Matheson, 2006) Runners usually suffer from stress fractures of the navicular bone, tibia, fibula, and metatarsal bones, while

metatarsal bones may also be injured in dancers. (Fredericson et al., 2006) The ulnar olecranon is the most common location of stress fractures in baseball players, while rib fractures are common among rowers. (Warden, Gutschlag, Wajswelner, & Crossley, 2002; Zaremski, Zeppieri, & Tripp, 2019) Stress fractures are often diagnosed late since the pain is vague and non-specific in location. The most common early radiographic evidence is periosteal apposition, which develops after three weeks of bone condensation at the fracture site. (Shanmugam & Maffulli, 2008) An MRI is usually performed to exclude an infection or tumor that could weaken the bone and cause a pathological fracture. (Shanmugam & Maffulli, 2008) Treatment consists of cast immobilization and avoiding weight bearing. If athletic triad or relative energy deficiency syndrome (RED-S) is known, the bone mineral density should be evaluated with a DEXA scan to exclude low bone mineral density. (Sweeney et al., 2020)

Spine

Spondylolysis and Pedicle Stress Fracture

Overuse syndromes in the lumbar spine are the second most common after overuse syndromes in the lower extremities. It is expected that 10 to 15 % of young athletes will experience lower back pain at some point throughout their sports career. However, the incidence among football players and gymnasts can be as high as 27 and 50 to 87 %, respectively. (De Luigi, 2014) Among those, weight lifters and dancers are known to be affected the most. (Congeni, McCulloch, & Swanson, 1997) Extreme movement of the lumbar spine, especially hyperextension and axial rotations, puts extensive stress on the posterior structures of the lumbar neural arch, resulting in a stress fracture of the pars interarticularis or spondylolysis, which may progress to a complete fracture and a slipped vertebrae or spondylolisthesis. A unilateral pedicle stress fracture often develops, which displays symptoms similar to spondylolysis. They include pain in the lower spine, exacerbated by hyperextension, and a positive Michelis' test. Although an X-ray may reveal the diagnosis, an MRI is performed to assess the compression of neural structures. Treatment consists of relative rest and avoiding strenuous activity for 4 to 6 weeks. (Herman, Pizzutillo, & Cavalier, 2003) Surgical management is suitable in the case of progression with signs of instability and spinal stenosis. (Wong, Lalam, Cassar-Pullicino, Tyrrell, & Singh, 2020)

PREVENTION

Many overuse injuries are avoidable; thus, prevention is critical. In recent years, the "Recommendations for the Prevention of Physical Activity-Related Injuries in Adolescents" were published. These recommendations were developed to provide guidance on how to prevent injuries related to physical activity among adolescents. (Mari & Jari, n.d.) The reader is invited to visit the link provided in the reference section.

Fatigue and decreased performance, in terms of both quality and quantity, are early signs of overuse injury. Early sport specialization, extensive year-round training to the exclusion of other sports (Myer et al., 2015), and a heavy training load are all connected to overuse injuries. (Sweeney et al., 2020) A young athlete's appropriate training load and rest to improve adaptation without increasing injury risk is most likely determined by a variety of factors, including physical maturity, fitness level, biomechanics, sport environment, and other things. (Brenner &Watson, 2024) For young and middle school athletes, a basic rule of thumb is to limit the hours spent in organized sports each week to fewer than the youth's age in years. (Jayanthi, LaBella, Fischer, Pasulka, & Dugas, 2015) In several sports, the injury risk is less than 10% when the acute/chronic load ratio (e.g., the previous week's training load or the 4-week rolling average of the load) is between 0.8 and 1.3. (Soligard et al., 2016)

In general, most recommendations made by sports medicine organizations and based on existing research in clinical and community-based cohorts of young athletes oppose early sport specialization, meaning that one should only specialize in a single sport after the age of 12. (Jayanthi, Post, Laury, & Fabricant, 2019)

Nonetheless, in addition to physical stress, the intense training associated with youth sports specialization tends to have a detrimental effect on an athlete's psychological well-being. It can lead to social isolation, altering an athlete's identity. (LaPrade et al., 2016) Perfectionism and unrealistic expectations set by parents and coaches present excessive psychological stress. (Bergeron et al., 2015) If an athlete cannot cope with the load, maladaptive coping strategies, loss of motivation, mood disturbances, and even burnout can follow. (LaPrade et al., 2016) Youth athletes must be involved in preventive management. (Launay, 2015) They should be adequately educated to listen to their own body and express the first signs of pain and discomfort in order to adjust their training routine, reduce the number of competitions, and start the proper rehabilitation before an overuse syndrome develops. Most sports organizations suggest that youth players take more than one month off from their sport in a year, pursue

fewer weekly training hours than their age, and have an established support system both in the sport and at home to reduce the psychological impacts of a professional sports career. (Jayanthi et al., 2019)

Although sports specialization has been associated with potentially harmful psychological health consequences, long-term impacts require more research. (Jayanthi et al., 2019)

CONCLUSION

Addressing the growing issue of overuse syndromes in young people requires a multi-faceted approach. This includes promoting sports diversification, educating athletes and parents about injury prevention, emphasizing the importance of rest and recovery, and fostering a balanced and healthy approach to physical activity.

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REPORTS AND REVIEWS
POROČILA IN OCENE

REPORTS AND REVIEWS/POROČILA IN OCENE, 177–183

CONFERENCE REPORT – THE 28th ANNUAL CONGRESS OF THE EUROPEAN COLLEGE OF SPORT SCIENCE

Paris, France, 4–7 July 2023

The French Institute of Sport (INSEP) hosted the 28th Annual Congress of the European College of Sport Science in Paris, France in the Palais des Congres congress venue. The theme of "Explore, enlighten, perform" guided the four-day congress featuring three plenary symposia offering six presentations and slots of invited sessions, exchange symposia, oral presentations and print posters. There was also an undebated section of e-posters. The diversity of topics covered provided a well-rounded perspective on the current state of sports science. Among the participants, colleagues from the Institute of Kinesiology Research of ZRS Koper presented their work: Miloš Kalc (*The reduction in h-reflex after short maximal isometric contractions is mediated by presynaptic inhibition mechanisms*), Manca Peskar (*Neurophysiological correlates of cognitive – motor dual – tasking in early Parkinsons disease during a balance*

task) and Katarina Puš (*The relevance of tensiomyography-derived skeletal muscle contractile properties in sarcopenic and non-sarcopenic participants*). Uroš Marušič attended the conference as a scientific committee member of the ECSS. In conclusion, the congress provided an invaluable platform for scientific discourse, fostering collaboration and contributing to the advancement of knowledge in the intricate realm of sports science.

The 29th Annual Congress of the European College of Sport Science will be hosted by the University of the West of Scotland in Glasgow, and the theme of the congress will be "Enhancing Health, Performance and Community Sport".

Katarina Puš

REPORTS AND REVIEWS/POROČILA IN OCENE, 177–183

POROČILO O KONFERENCI – 28. LETNI KONGRES EVROPSKEGA ZDRUŽENJA ŠPORTNIH ZNANOSTI

Pariz, Francija, 4.–7. julij 2023

Francoski inštitut za šport (INSEP) je 28. letni kongres Evropskega združenja športnih znanosti gostil v francoski prestolnici, natančneje v kongresnem centru Palais des Congres. Slogan letošnjega kongresa »Razišči, osvetli, izvedi« je vodil štiridnevni kongres, na katerem so potekali trije plenarni simpoziji s šestimi predavanji in številna vabljena predavanja, ustne predstavitve in predstavitve posterjev, objavljeni pa so bili tudi e-posterji. Raznolikost predstavljenih tem je omogočila celosten vpogled v trenutno stanje športne znanosti z več področij.

Med sodelujočimi so bili tudi sodelavci Inštituta za kineziološke raziskave ZRS Koper, ki so predstavili svoje delo: Miloš Kalc (*The reduction in h-reflex after short maximal isometric contractions is mediated by presynaptic inhibition mechanisms*), Manca Peskar (*Neurophysiological correlates of cognitive – motor dual – tasking in early Parkinsons disease during a balance task*) in Katarina Puš (*The relevance of tensiomyography-derived skeletal muscle contractile properties in sarcopenic and non-sarcopenic participants*). Kongresa se je kot član znanstvenega odbora udeležil tudi Uroš Marušič.

Kongres je zagotovil neprecenljivo platformo za znanstvene diskusije, spodbudil mednarodno sodelovanje in prispeval k napredku znanja na področju športne znanosti.

29. letni kongres Evropskega združenja športnih znanosti bo gostila univerza zahodne Škotske v Glasgowu, naslov kongresa pa bo »Krepitev zdravja, zmogljivosti in skupnostnega športa«.

Katarina Puš

REPORTS AND REVIEWS/POROČILA IN OCENE, 177–183

12th INTERNATIONAL SCIENTIFIC AND PROFESSIONAL CONFERENCE "A CHILD IN MOTION"

Portorož, Slovenia, 2–4 October 2023

For many years, the International Scientific and Professional Conference "A Child in Motion" has been drawing attention to the lack of physical activity among children and adolescents. This year's conference coincided with World Children's Week and highlighted the key issues facing children and adolescents. The conference theme focused on increasing screen time, rising physical inactivity and childhood obesity, summarizing these issues under the working title "Change the game – a modern way back to the roots". The aim of this year's conference was to shed light on these challenges and at the same time look for new solutions, including through ICT.

The two-day program included 2 plenary speakers and 4 keynote speakers who presented current research findings. The Book of Abstracts contains 41 scientific and 64 professional abstracts and, new this year, 3 professional papers. The contributions come from more than 200 authors and co-authors from 11

European countries. The contributions present both current research findings and examples of good practice from educators, kinesiologists, psychologists, nutritionists, and others on the topic of the imbalance between screen time and physical activity in the daily rhythms of children and adolescents. This international colorfulness is certainly due to the successful multi-year partnership between national and international universities and professional associations and supporters of the conference. We are proud that this year's conference was held under the honorable patronage of the President of the National Assembly of the Republic of Slovenia, Urška Klakočar Zupančič, who recognized the efforts and supported the mission of this long-standing tradition.

The positive feedback from the conference participants confirms that the in-person conference is not only useful for the presentations, but also as an excellent opportunity for networking, sharing successful practices and meeting new people during the coffee breaks and social events.

Kaja Teraž and Saša Pišot

REPORTS AND REVIEWS/POROČILA IN OCENE, 177–183

12. MEDNARODNA ZNANSTVENA IN STROKOVNA KONFERENCA »OTROK V GIBANJU«

Portorož, Slovenija, 2.–4. oktober 2023

Mednarodna znanstvena in strokovna konferenca Otrok v gibanju že številna leta opozarja na pomanjkanje gibalno-športnih aktivnosti med otroki in mladostniki. Letošnja konferenca je sovpadala s svetovnim tednom otroka in je poudarila ključne problematike, s katerimi se sooča populacija otrok in mladostnikov. Tema konference je postavila v središče povečan čas pred zasloni, naraščajočo gibalno neaktivnost ter čezmerno telesno maso otrok in mladostnikov, omenjene teme pa zajela z delovnim naslovom konference Spremenimo igro – s sodobnimi pristopi nazaj k osnovam. Cilja letošnje konference sta bila izpostavitev omenjenih izzivov in hkratno iskanje novih rešitev, tudi s pomočjo IKT.

Dvodnevni program je ponudil dve plenarni in štiri uvodna predavanja, v katerih so predavatelji predstavili aktualna dognanja. Zbornik prispevkov vsebuje 41 znanstvenih prispevkov in 64 strokovnih povzetkov prispevkov,

letošnja novost pa so trije dolgi strokovni prispevki. Dela so vir več kot 200 avtorjev in soavtorjev iz 11 evropskih držav ter predstavljajo aktualna raziskovalna dognanja in tudi primere dobrih praks pedagoških delavcev, kineziologov, psihologov, dietetikov in drugih na temo neuravnoteženosti med zaslonskim in gibalno aktivnim časom v dnevnem ritmu otrok in mladostnikov. Ta mednarodna barvitost je gotovo zasluga uspešnega večletnega partnerstva domačih in tujih univerz ter poklicnih združenj in podpornikov konference. Ponosni smo, da je letošnja konferenca potekala pod častnim pokroviteljstvom predsednice Državnega zbora RS mag. Urške Klakočar Zupančič, ki je prepoznala trud in podprla poslanstvo večletne tradicije.

Odzivi udeležencev konference potrjujejo, da konferenca »v živo« ni koristna samo zaradi predavanj, temveč je tudi odlična priložnost za povezovanje, izmenjavo uspešnih praks ter spoznavanje novih ljudi med odmori za kavo in družabnimi dogodki.

Kaja Teraž in Saša Pišot

GUIDELINES FOR AUTHORS, 185–188

GUIDELINES FOR AUTHORS

1. Aim and scope of the journal:

Annales Kinesiologiae is an international interdisciplinary journal covering kinesiology and its related areas. It combines fields and topics directed towards the study and research of human movement, physical activity, exercise and sport in the context of human life style and influences of specific environments. The journal publishes original scientific articles, review articles, technical notes and reports.

2. General policy of Annales Kinesiologiae

Annales Kinesiologiae pursues the multi-disciplinary aims and nature of Kinesiology with the main goal to promote high standards of scientific research.

a) Reviewing: Each manuscript, meeting the technical standards and falling within the aims and scope of the journal, will be subjected to a double-blind peer-review by two reviewers. Authors can propose up to two reviewers for revision of their work and also up to two reviewers they would like to avoid.

The referees are chosen by the Editors. Assessments by the referees will be presented anonymously to the author and will be returned to the author for correction. The corrected copy of the manuscript, with the list of corrections on a separate page, should be returned to the responsible Editor.

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3. Manuscript preparation

a) Language and style: The language of Annales Kinesiologiae is USA English. The authors are responsible for the language, grammar, and style of the manuscript, which need to meet the criteria defined in the guidelines for authors. Manuscripts are required to follow a scientific style style. The journal will be printed in grayscale.

b) The length of the manuscript should not exceed 36,000 characters (excluding spaces).
Text formatting: It is required to use the automatic page numbering function to number the pages. Times New Roman font size 12 is recommended, with double spacing between lines. Use the table function, not spreadsheets, to make tables. Use an equation editor for equations. Finally, all lines need to be number, were the first line of a pages is assigned line number 1.

c) Miscellaneous: Whenever possible, use the SI units (Système international d'unités).

d) The **title page** should include the title of the article (no more than 85 characters, including spaces), full names of the author(s) and affiliations (institution name and address) of each author; linked to each author using superscript numbers, as well as the corresponding author's full name, telephone, and e-mail address.

e) The authors are obliged to prepare two **abstracts** – one short abstract in English and one (translated) in Slovene language. For foreign authors translation of the abstract into Slovene will be provided. The content of the abstract should be structured into the following sections: purpose, methods, results, and conclusions. It should only contain the information that appears in the main text, and should not contain reference to figures, tables and citations published in the main text. The abstract is limited to 250 words.

f) Under the abstract a maximum of 6 appropriate **Keywords** shall be given in English and in Slovene. For foreign authors the translation of the key words into Slovene will be provided.

g) The **main text** should include the following sections: Introduction, Methods, Results, Discussion, Conclusions, Acknowledgement (optional), and References. Individual parts of the text can form sub-sections.

h) Each **table** should be submitted on a separate page in a Word document after the Reference section. Tables should be double-spaced. Each table shall have a brief caption; explanatory matter should be in the footnotes below the table. Abbreviations used in the tables must be consistent with those used in the main text and figures. Definitions of symbols should be listed in the order of appearance, determined by reading horizontally across the table and should be identified by standard symbols. All tables should be numbered consecutively Table 1, etc. The preferred location of the table in the main text should be indicated preferably in a style as follows: *** Table 1 somewhere here ***.

i). Captions are required for all **figures** and shall appear on a separate manuscript page, under the table captions. Each figure should be saved as a separate file without captions and named as Figure 1, etc. Files should be submitted in *.tif or *.jpg format. The minimum figure dimensions should be 17x20 cm and a resolution of at least 300 dpi. Combinations of photo and line art should be saved at 600–900 dpi. Text (symbols, letters, and numbers) should be between 8 and 12 points, with consistent spacing and alignment. Font type may be Serif (Times Roman) or Sans Serif (Arial). Any extra white or black space surrounding the image should be cropped. Ensure that participant-identifying information (i.e., faces, names, or any other identifying features) should be omitted. Each figure should be saved as a separate file without captions and named as Figure 1, etc. The preferred location of the figure in the main text should be indicated preferably in a style as follows: *** Figure 1 somewhere here ***.

j) References

The journal uses the Harvard reference system (Publication Manual of the American Psychological Association, 6th ed., 2010), see also: https://www.apastyle.org). The list of references should only include work cited in the main text and being published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text. References should be complete and contain up to seven authors. If the author is unknown, start with the title of the work. If you are citing work that is in print but has not yet been published, state all the data and instead of the publication year write „in print".

Reference list entries should be alphabetized by the last name of the first author of each work. Titles of references written in languages other than English should be additionally translated into English and enclosed within square brackets. Full titles of journals are required (no abbreviations).

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Examples of reference citation in the text

One author: This research spans many disciplines (Enoka, 1994) or Enoka (1994) had concluded...

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Three to six authors:
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Examples of reference list*:*
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Books
Latash, M. L. (2008). Neurophysiologic basis of movement. Campaign (USA): Human Kinetic.

Journal articles
Marušič, U., Meeusen, R., Pišot, R., & Kavcic, V. (2014). The brain in micro- and hypergravity : the effects of changing gravity on the brain electrocortical activity. European journal of sport science, 14(8), 813–822. https://doi.org/10.1080/17461391.2014.908959

Šimunič, B., Koren, K., Rittweger, J., Lazzer, S., Reggiani, C., Rejc, E., … Degens, H. (2019). Tensiomyography detects early hallmarks of bed-rest-induced atrophy before changes in muscle architecture. Journal of applied physiology, 126(4), 815–822. https://doi.org/10.1152/japplphysiol.00880.2018

Book chapters

Šimunič, B., Pišot, R., Mekjavić, I. B., Kounalakis, S. N. & Eiken, O. (2008). Orthostatic intolerance after microgravity exposures. In R. Pišot, I. B. Mekjavić, & B. Šimunič (Eds.), The effects of simulated weightlessness on the human organism (pp. 71–78). Koper: University of Primorska, Scientific and research centre of Koper, Publishing house Annales.

Rossi, T., & Cassidy, T. (in press). Teachers' knowledge and knowledgeable teachers in physical education. In C. Hardy, & M. Mawer (Eds.), Learning and teaching in physical education. London (UK): Falmer Press.

Conference proceeding contributions

Volmut, T., Dolenc, P., Šetina, T., Pišot, R. & Šimunič, B. (2008). Objectively measures physical activity in girls and boys before and after long summer vacations. In V. Štemberger, R. Pišot, & K. Rupret (Eds.) Proceedings of 5th International Symposium A Child in Motion "The physical education related to the qualitative education" (pp. 496–501). Koper: University of Primorska, Faculty of Education Koper, Science and research centre of Koper; Ljubljana: University of Ljubljana, Faculty of Education.

Škof, B., Cecić Erpić, S., Zabukovec, V., & Boben, D. (2002). Pupils' attitudes toward endurance sports activities. In D. Prot, & F. Prot (Eds.), Kinesiology – new perspectives, 3rd International scientific conference (pp. 137–140), Opatija: University of Zagreb, Faculty of Kinesiology.

4. Manuscript submission

The article should be submitted via online Open Journal Systems application, which is open source journal management and publishing software at http://ojs.zrs-kp.si/index.php/AK/about/submissions. All the communication process with authors proceeds via Open Journal System and e-mail.

5. For additional information regarding article publication, please do not hesitate to contact the secretary of Annales Kinesiologiae.


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ISSN 2232-2620