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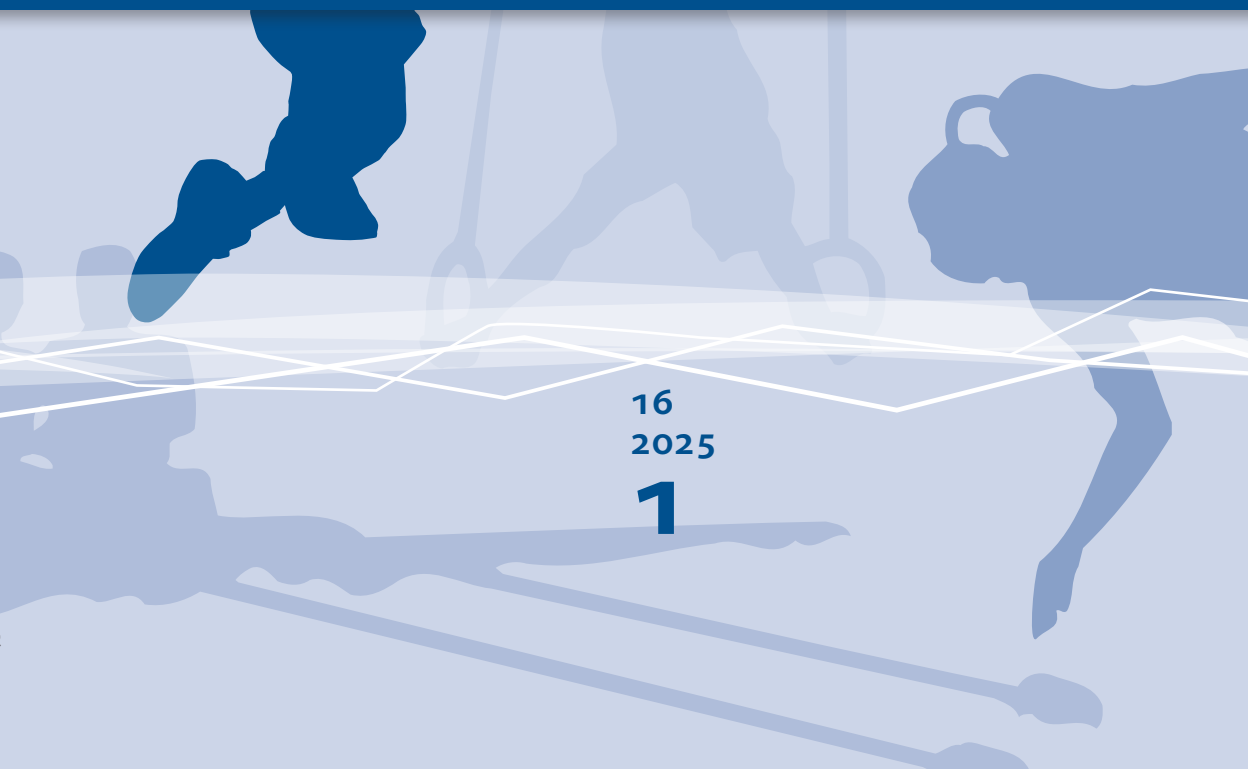

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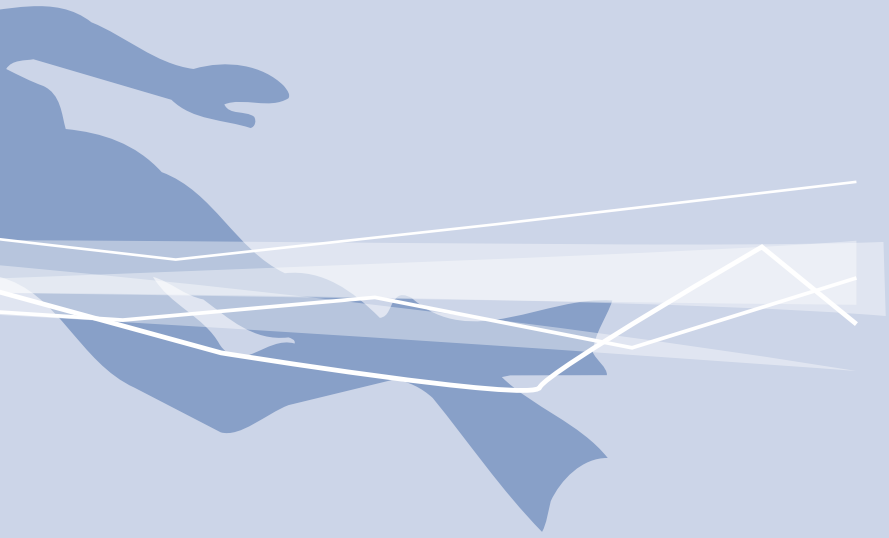

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OCENE IN POROČILA

EDITORIAL

In 2025, Annales Kinesiologiae proudly presents Volume 16, Issue 1, showcasing a diverse and timely selection of studies and reports that mirror the increasing complexity and interdisciplinarity of contemporary health and movement sciences. The research featured in this issue addresses both foundational and emerging public health concerns, ranging from menstrual health in elite athletes to cardiovascular risk in children and sedentary lifestyle challenges in the workplace.

The opening original scientific article by Bunn, Marchelli and Humphries explores a frequently overlooked aspect of athletic performance—the menstrual cycle and its symptomatic manifestations in Division I female lacrosse athletes. Their prospective observational study not only quantifies symptom prevalence but also underscores the potential role of hormonal contraceptives in mood regulation. With the increasing attention paid to athlete mental health and individualised training, this research is both practical and progressive in promoting performance-aware menstrual tracking in team sport settings.

Addressing the physical activity behaviours of the youngest population, Brumnić, Šalaj and Pišot investigate screen time and movement in Croatian preschoolers. Their findings reveal how parental education and active engagement are key determinants of early lifestyle patterns, highlighting a crucial window for interventions. As screen exposure among children remains a global concern, this study offers relevant insights for educators, caregivers and policymakers aiming to cultivate healthier routines in early childhood.

Addressing challenges in adult workplace health, a study on the effects of booster breaks by Uršič and Marušič presents compelling evidence that short, structured physical activity breaks during working hours can significantly reduce the intensity of non-specific low back pain, a condition increasingly prevalent in sedentary professions, and enhance overall well-being. In an increasingly sedentary work culture—exacerbated by remote and hybrid job models—this research offers a practical, scalable intervention that combines ergonomics with preventive health promotion.

In a systematic review by Contreras-Zapata and colleagues, evidence-based strategies for managing cardiovascular risk in children are created. The review reinforces that structured physical activity—especially programmes combining aerobic and resistance training with nutritional or behavioural components—can yield meaningful reductions in blood pressure, cholesterol and body fat. Particularly notable is the emphasis on family and school involvement, which

boosts adherence and long-term outcomes, aligning with preventive strategies in paediatric public health.

This issue also features compelling reports, including the NeuroPlay Project by Marušič and Pišot, which proposes intergenerational play as a means to stimulate neuroplasticity throughout the lifespan. Additionally, Peskar reflects on the significance of recognition through the L'Oréal-UNESCO Prize 'For Women in Science', underscoring the importance of gender equity in scientific research and leadership.

An engaging infographic by Paravlić et al. visually compares vascular responses to high-intensity intervals versus moderate continuous exercise—adding an accessible and visually impactful element to this issue.

Collectively, these contributions highlight the centrality of movement, equity and context in shaping public health interventions throughout the lifespan. As physical inactivity, screen dependence and gender-specific health issues continue to challenge public health systems, the research in this issue offers direction for evidence-based policies and interventions tailored to diverse populations.

We invite readers to explore, share and engage with the findings presented in this volume, and we thank all the contributors for their valuable work. Let this issue serve not only as a reflection of the current research but as a call for continued innovation and collaboration in advancing human health through science.

Prof Dr Boštjan Šimunič,
Editor

UVODNIK

Uredništvo vam z veseljem predstavlja prvo številko revije Annales Kinesiologiae v letu 2025, letnik 16, ki prinaša raznolik in aktualen izbor študij in poročil, ki izražajo vse večjo kompleksnost in interdisciplinarnost sodobnih ved o zdravju in gibanju. Raziskave, predstavljene v tej številki, obravnavajo temeljne in tudi nove probleme javnega zdravja, od menstrualnega zdravja pri vrhunskih športnicah do srčno-žilnega tveganja pri otrocih in izzivov sedečega načina življenja na delovnem mestu.

V uvodnem izvirnem članku Bunn, Marchelli in Humphries raziskujejo pogosto spregledan vidik športne uspešnosti – menstrualni cikel in njegove simptomatske manifestacije pri športnicah divizije I v lakrosu. Njihova prospektivna opazovalna študija ne kvantificira le razširjenosti simptomov, temveč tudi poudarja potencialno vlogo hormonskih kontracepcijskih sredstev pri uravnavanju počutja. Ob vse večji pozornosti, namenjeni duševnemu zdravju športnikov in individualiziranemu treningu, je ta raziskava praktična in napredna pri spodbujanju spremljanja menstruacije in vpliva na uspešnost, v okolju ekipnih športov.

Brumnić, Šalaj in Pišot se ukvarjajo s telesno aktivnostjo najmlajše populacije ter raziskujejo čas pred zaslonom in gibanje pri hrvaških predšolskih otrocih. Njihove ugotovitve razkrivajo, da sta vzgoja staršev in aktivno udejstvovanje izjemno pomembna dejavnika zgodnjih vzorcev življenjskega slogain ključna za intervencije. Ker izpostavljenost otrok zaslonom ostaja globalna težava, ta študija ponuja pomembna spoznanja za vzgojitelje, skrbnike in oblikovalce politik, cilj katerih je vzpostaviti bolj zdrave rutine v zgodnjem otroštvu.

Študija avtorjev Uršičeve in Marušiča, ki obravnava izzive na področju zdravja odraslih na delovnem mestu, ponuja prepričljive dokaze, da lahko kratki strukturirani odmori za telesno aktivnost med delovnim časom znatno zmanjšajo intenzivnost nespecifičnih bolečin v križu, ki so vse pogostejše v sedečih poklicih, in izboljšajo splošno dobro počutje. V vse bolj sedeči delovni kulturi, ki jo še poslabšujejo modeli dela na daljavo in hibridni modeli dela, ta raziskava ponuja praktičen, razširljiv ukrep, ki združuje ergonomijo s preventivnim spodbujanjem zdravja.

Contreras-Zapata in sodelavci so v sistematičnem pregledu povzeli z dokazi podprte strategije za obvladovanje srčno-žilnega tveganja pri otrocih. Pregled potrjuje, da lahko strukturirana telesna dejavnost – zlasti programi, ki združujejo aerobno in odpornostno vadbo s prehranskimi ali vedenjskimi komponentami – pomembno zniža krvni tlak, holesterol in telesne maščobe. Posebej je treba poudariti vključevanje družine in šole, ki povečujeta

pripadnost in dolgoročne rezultate, kar se ujema s preventivnimi strategijami na področju pediatričnega javnega zdravja.

V tej številki revije so objavljena tudi zanimiva poročila, med drugim o projektu NeuroPlay Marušiča in Pišota, ki predlaga medgeneracijsko igro kot sredstvo za spodbujanje nevroplastičnosti v celotnem življenjskem obdobju. Poleg tega Manca Peskar razmišlja o pomenu priznanja z nagrado L'Oréal-UNESCO Za ženske v znanosti, ki poudarja pomen enakosti spolov pri znanstvenem raziskovanju in vodenju.

Zanimiva infografika Paravlića in soavtorjev vizualno primerja odzive ožilja na visoko intenzivno intervalno vadbo v primerjavi z zmerno neprekinjeno vadbo, kar ponuja razumljiv in vizualno učinkovit način predstavitve tega vprašanja.

Ti prispevki skupaj poudarjajo osrednjo vlogo gibanja, enakosti in konteksta pri oblikovanju ukrepov za javno zdravje v celotnem življenjskem obdobju. Ker telesna nedejavnost, odvisnost od zaslonov in zdravstvena vprašanja, povezana s spolom, vedno znova postavljajo izzive sistemom javnega zdravja, raziskave v tej številki ponujajo smernice za politike in ukrepe, ki temeljijo na dokazih in so prilagojeni različnim populacijam.

Bralce vabimo k raziskovanju, delitvi in sodelovanju z ugotovitvami, predstavljenimi v tem zvezku, vsem avtorjem pa se zahvaljujemo za njihovo dragoceno delo. Naj ta številka ne izraža le trenutnih raziskav, temveč naj tudi poziva k nadaljnjim inovacijam in sodelovanju pri razvoju zdravja ljudi s pomočjo znanosti.

Prof. dr. Boštjan Šimunič,
urednik

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MENSTRUAL SYMPTOMS IN DIVISION I FEMALE ATHLETES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Purpose: *To quantify the frequency of menstrual cycle (MC) symptoms experienced by Division I female lacrosse athletes and to discover if the symptoms were different among those who were taking a hormone contraceptive (HC) compared to those who were not (non-HC).*

Methods: *As part of a daily wellness survey, athletes (non-HC = 10, HC = 11) were asked if they were menstruating. If they were, they were asked to identify any symptoms they were experiencing. The symptoms were recorded for each day of menstruation during their four-month competitive season. Reported symptoms were categorized as frequently, sometimes, rarely, or never. The frequencies of symptoms were tabulated in total and per cycle for each group.*

Results: *The most frequently reported symptom was cramps with 90.4% of athletes reporting experiencing it at least once. Headaches (66%), back pain, and skin problems (57% each) were also frequently reported. HC users (0.7 ± 1.4 times/cycle) reported mood swings more frequently than non-HC users (0.03 ± 0.08, p = 0.029), but there were no other group differences for symptoms.*

Conclusions: *Tracking symptoms associated with MC can help athletes and coaches be aware of patterns and incorporate methods for mitigating or alleviating the symptoms. Symptom tracking can also help athletes mentally prepare for the effects of their*

MC on training and performance. More research is needed before recommending HC use as a management strategy for menstrual symptoms.

Keywords: *menstrual cycle, team sport, hormone contraceptive*

MENSTRUALNI SIMPTOMI PRI ŠPORTNICAH DIVIZIJE I: PROSPEKTIVNA OPAZOVALNA RAZISKAVA

IZVLEČEK

Namen: *Kvantificirati, kako pogosto doživljajo simptome menstrualnega cikla (MC) igralke lakrosa divizije I, in primerjati, ali se simptomi razlikujejo med športnicami, ki uporabljajo hormonsko kontracepcijo (HK), in tistimi, ki je ne (ne-HK).*

Metodologija: *V okviru dnevne ankete o počutju so morale športnice (ne-HK = 10, HK = 11) vsak dan odgovoriti, ali menstruirajo. Če so odgovorile pritrdilno, so bile pozvane k opisu simptomov. Simptome so zapisovale vsak dan menstruacije v štirimesečnem obdobju tekmovalne sezone. Poročani simptomi so bili razvrščeni v kategorije pogosto, občasno, redko ali nikoli. Pogostost simptomov je bila predstavljena v tabelarni obliki, in sicer skupno ter na cikel za vsako skupino posebej.*

Rezultati: *Najpogostejši simptom, o katerem so poročale športnice, so bili krči in kar 90,4 % športnic je navedlo, da so ta simptom doživele vsaj enkrat. Pogosto so poročale tudi o glavobolih (66 %), bolečinah v hrbtu in težavah s kožo (oboje 57 %). Uporabnice HK (0,7 ± 1,4-krat/cikel) so pogosteje opažale nihanje razpoloženja od tistih, ki ne uporabljajo HK (0,03 ± 0,08, p = 0,029), pri čemer ni bilo drugih razlik glede simptomov med skupinama.*

Zaključki: *Spremljanje simptomov, povezanih z MC, lahko športnicam in trenerjem pomaga prepoznati vzorce ter v delo vključiti načine za ublažitev ali lajšanje simptomov. Poleg tega se lahko športnice s spremljanjem simptomov psihično pripravijo na to, kako njihov MC vpliva na trening in zmogljivost. Potrebnih je več raziskav, preden bo mogoče HK priporočati kot strategijo za obvladovanje menstrualnih simptomov.*

Ključne besede*: menstrualni cikel, ekipni šport, hormonska kontracepcija*

INTRODUCTION

The menstrual cycle (MC) is broken down into three phases: 1) the follicular phase, 2) the ovulatory phase, and 3) the luteal phase. The follicular phase begins with the onset of menses and concludes when estrogen levels rise to begin the ovulatory phase. The ovulatory phase concludes when estrogen levels decline and progesterone levels increase to begin the luteal phase. The MC has been shown to affect thermoregulatory, respiratory, metabolic, and cardiovascular parameters with equivocal effects on endurance performance (Julian, Hecksteden, Fullagar, & Meyer, 2017). The MC is also accompanied by a variety of physiological, physical, and emotional symptoms. The proposed mechanisms for these symptoms include alterations in the central nervous system (Yonkers & Simoni, 2018), changes in the release of inflammatory markers (Puder et al., 2006), reactive oxygen species (Ma et al., 2013), and hormone sensitivities and fluctuations (Gaskins et al., 2012).

Two recent reviews showed that the effects of the MC on exercise performance were equivocal across several performance characteristics, including: aerobic capacity, anaerobic power, muscular strength, speed, and muscular power (Carmichael, Thomson, Moran, & Wycherley, 2021; Vogel, Larsen, McLellan, & Bird, 2024). However, most of the studies focused on controlled laboratory exercise tests instead of training or game performance. How an athlete performs on a laboratory test may not directly carry over to game day performance. Gasperi, Sansone, Gómez-Ruano, Lukonaitienė, and Conte (2023) showed evidence that basketball players experienced improved shooting and rebounding during the follicular phase, further suggesting that exercise performance and game performance are not the same. The use of microtechnology allows for evaluation of performance during training and games, and evidence shows no overall difference in college athletes when menstruating (Humphries, Marchelli, & Bunn, 2024). However, there is some concern about the reduced performance of hormone contraceptive (HC) users. Bozzini, McFadden, Elliott-Sale, Swinton, and Arent (2021) assessed Division I soccer players weekly throughout their 15-week competitive season and found that HC users consistently had a lower external load and energy expenditure compared to non-HC users. Humphries et al. (2024) also showed that HC users had a 1-5% decline in game day performance during their withdrawal bleed. This was not a statistical difference, but it would likely still be impactful in relation to game performance (Thornton, Figueroa, Davis, & Bunn, 2023).

The MC is also believed to have a psychological effect on athletes, which may subsequently affect performance. Athletes across competitive levels

believe that their MC has impacted their training or performance (Bruinvels et al., 2021; Findlay, Macrae, Whyte, Easton, & Forrest, 2020; Martin, Sale, Cooper, & Elliott-Sale, 2018; Oester et al., 2024). Symptoms include a perceived negative effect on performance, fatigue, mood disturbances, poor coordination, reduced motivation, feeling tearful and emotional, feelings of agitation, and poor concentration (Brown, Knight, & Forrest, 2021; Findlay et al., 2020; Marchelli, Humphries, & Bunn, 2025; O'Brien, Rapkin, Dennerstein, & Nevatte, 2011). Professional rugby players have perceived a loss of strength, appetite, and focus, as well as heightened emotions and fatigue (Hayward, Akam, Hunter, & Mastana, 2024), and nutritional strategies may be useful in mitigating these symptoms (Brown et al., 2024). Qualitative studies have also shown that athletes feel worry and fear in relation to experiencing menstrual flooding during competition and training (Findlay et al., 2020). Athletes also feel increased anxiety with standardized uniforms that may be revealing or include white shorts or pants (Findlay et al., 2020). Avoiding harm, adjusting energy, awareness and acceptance, and self-care were identified as coping strategies to mitigate the effects of MC (Modena, Bisagno, Schena, Carazzato, & Vitali, 2022). To date, longitudinal studies have shown no differences in sleep quality, sleep duration, muscle soreness, nutrition, and health across MC phases in collegiate and elite-level athletes (Marchelli et al., 2025; Scott, Bruinvels, Norris, & Lovell, 2024).

These perceptions are often linked to the physical symptoms experienced by female athletes during their pre-menstrual phase and during menses. Physical symptoms typically include abdominal cramping/pain, skin changes, bloating, appetite changes, breast tenderness, low back pain, gastrointestinal disturbances, and headaches (Brown et al., 2021; Bruinvels et al., 2021; Findlay et al., 2020; Martin et al., 2018; McKay et al., 2024; Roffler, Fleddermann, de Haan, Krüger, & Zentgraf, 2024; Taim et al., 2023). Affective symptoms such as mood changes, sleep disturbances, fatigue, and difficulties concentrating have also been reported (Taim et al., 2023). Most of these symptoms are reported during the initial days of menstruation (Martin et al., 2018; Taim et al., 2023). The Menstrual Symptoms index (MSi) was created to help evaluate the frequency of these symptoms (Bruinvels et al., 2021). The MSi categorizes the symptoms by frequency of experience for non-HC users and the scores range from zero to 54. The mean MSi score in general female exercisers was 22.9, and a higher MSi was associated with missing/changing a training session or sporting event, missing work, and use of pain medication (Bruinvels et al., 2021). This aligns with research on elite athletes indicating a negative correlation between the perceived performance and the presence of menstrual

cycle symptoms (Antero et al., 2023). Helping athletes recognize and manage symptoms has been recognized as a prudent approach to ensuring the readiness of athletes to train and compete (McGawley et al., 2023; McNamara, Harris, & Minahan, 2022; Taim et al., 2023).

Approximately 40–50% of female athletes use HCs with varying hormone levels and types (Martin et al., 2018). There are two main types of oral contraceptives: the combined pill (which contains both estrogen and progestin) and the mini pill (which contains only progestin) (Powell, 2017). These are typically taken daily for three weeks, followed by a week off each month. Other contraceptive options include implants, hormonal intrauterine devices (IUDs), and injections, all of which contain only progestin (Powell, 2017). Contraceptive patches and vaginal rings release both estrogen and progesterone (Martin et al., 2018). Martin et al. (2018) reported that 77% of HC users experience negative symptoms associated with their MC, and the reported positive effects of HC use includes regular periods, less frequent periods, reduced bleeding, the ability to predict or change their cycle date, and improved skin (Martin et al., 2018). Common reported negative side effects of HC use include weight gain, irregular periods, poor skin, and mood changes (Martin et al., 2018). McKay et al. (2024) examined the difference in MC symptoms for non-HC and HC users during a high-performance camp. The results showed no difference in the symptoms reported in the groups, except that non-HC athletes had a higher prevalence of acne than the HC users. Roffler et al. (2024) tracked the menstrual symptoms of professional volleyball athletes and calculated the MSi, finding that the average number of symptoms reported per cycle was 11.8 ± 17.7 (Bruinvels et al., 2021; Roffler et al., 2024). Roffler calculated the MSi for both HC users and naturally cycling athletes, and the results showed a mean MSi of 12.5 ± 10.7 for non-HC users and 11.1 ± 4.7 for HC users.

With the recent focus on the MC and female athletes, research has provided equivocal evidence about exercise performance and that MC symptoms affect the athlete both physically and psychologically (McKay et al., 2024; Roffler et al., 2024). However, there is little evidence comparing these concepts between HC and non-HC users. This is especially important as there is a gap in addressing female-specific health issues in athlete preparticipation exams (Schulz, Pohlod, Myers, Chung, & Thornton, 2024), and because many athletes seek to use HCs to mitigate their MC symptoms or gain control over the timeliness of their menses (Martin et al., 2018). The purpose of this study was to quantify the frequency of MC symptoms experienced by Division I female lacrosse athletes and to see if the symptoms were different among those who were and were not taking a HC. We hypothesized that abdominal cramps would

be the most frequently reported symptom and that non-HC users would experience more symptoms than HC users.

MATERIALS AND METHODS

Study Design

This was a prospective observational study. Data were collected during the competitive season in Division I women's lacrosse for 3.5 months. All the data were self-reported by the participants. All the participants completed an informed consent prior to study participation. This study was approved by the institutional review board (CUIRB-705) and conducted in accordance with the Declaration of Helsinki.

Participants

Athletes were included in this study if they were members of the varsity women's lacrosse team at a given university and had been cleared for play. Athletes were excluded if they did not experience menses or a withdrawal bleed during the time of the study (n = 6) or missed significant time during the study due to injury or illness (n = 2). The athletes completed a shortened menstrual status questionnaire to indicate their status as an HC user or not (Bozzini et al., 2021; Humphries et al., 2024). There were 10 non-HC athletes and 11 HC users, with 10 taking an oral contraceptive and one using an intrauterine device. The mean age of the 21 athletes included in the study was 20.3 ± 1.4 years.

Measurements

Athletes were asked each morning via a smartphone survey (Metrifit, Louth, Ireland) whether or not they were menstruating. If they were not menstruating, no further information was gathered. If they were menstruating, they were asked to identify any symptoms they were experiencing in relation to their MC. The athletes could select as many symptoms as they wanted from the following list: cramping, headache, skin problems, bloating, back pain, nausea, fatigue,

mood swings, stress, and tenderness. This survey accompanied their daily wellness survey (data not included in the present study), and compliance was tracked daily by the research personnel.

The Metrifit system tracked the menstruation cycles of each athlete for the duration of the season and calculated the average length of their cycle and the average number of days they menstruated per cycle.

Symptoms were tabulated as a total for each group and by average per MC of the athlete. The symptoms were also categorized as occurring "often" if they appeared in each MC (3 points), "sometimes" if the symptoms appeared every two cycles (2 points), "rare" if the symptom appeared fewer than two times (1 point), and "never" if the symptom never appeared (0 points) (Bruinvels et al., 2021). This method is similar to that used for calculating the MSi, but the MSi uses 18 symptoms, and the present study only included ten.

Data Analysis

The frequency of the symptoms reported by all the athletes and for each group were tabulated in total and per cycle. The mean length of the MC, the number of days menstruating, and the number of cycles observed were calculated per group. A Shapiro-Wilk test determined that the data were not normally distributed, so the group differences in the number of cycles, cycle length, number of days menstruating, and the symptoms reported per cycle were determined via Mann-Whitney U tests with an alpha level of 0.05. Cohen's d effect sizes were calculated to determine the magnitude of the differences and interpreted as small (0.2), moderate (0.5), and large (0.8) (Cohen, 1988). Comparing symptoms in HC and non-HC users is fairly new, thus we did not use a Bonferroni correction. Instead, groups were determined to be different if the p-value was below the alpha level and had at least a moderate effect size.

RESULTS

More cycles were observed from HC users (3.6 ± 0.5 cycles) than non-HC users (2.8 ± 0.8 cycles) during the observed time ($U = 26.0$, $p = 0.031$, $d = 0.527$, moderate). The cycle length for the HC users was 27.8 ± 4.0 days and 33.0 ± 10.2 days for the non-HC users ($U = 31.0$, $p = 0.098$, $d = 0.436$, moderate), and 80% of the non-HC users were eumenorrheic. The number of

menstruating days for the HC users was 5.7 ± 1.5 days and 6.2 ± 2.5 days for the non-HC users (U = 51.0, p = 0.805, d = 0.073, small). Table 1 shows the frequency of symptoms reported per athlete per cycle for each group. The HC users experienced mood swings more frequently than the non-HC users (U = 33.0, p = 0.029, d = 0.400, moderate), but there were no other group differences for the other symptoms reported.

Figure 1 shows the percentage of athletes who reported each symptom at least once. Cramps and headaches were the two most frequently reported symptoms for all the athletes at 90.4% and 66.6%, respectively. Nausea and tenderness were reported with the lowest frequency, with only 23.8% of athletes reporting them. Two athletes, one HC user and one non-HC user, did not report any symptoms related to menstruation during the study. Figure 2 shows the percentage of athletes, regardless of group, reporting each symptom and the frequency of the categories for "often", "sometimes", "rare", and "never". Cramps were experienced often by 42.9% of the athletes, followed by back pain for 33.3% of the athletes. Skin breakouts were experienced "sometimes" by 42.9% of the athletes, and headaches were experienced "rarely" by 28.6% of the athletes. Tenderness, nausea, mood swings, fatigue, and bloating were never experienced by two-thirds or more of the athletes.

*Table 1: The frequency (mean ± standard deviation) of symptoms experienced per athlete per cycle. The results of the inference tests and effect sizes are also provided. * indicates a difference between the groups, $p < 0.05$.*

	HC User	Non-HC User	U (sig)	Effect size
Cramps	1.9 ± 1.5	2.4 ± 2.8	52.5 (0.444)	0.046 (small)
Headache	0.6 ± 0.8	1.1 ± 1.1	42.0 (0.834)	0.236 (small)
Skin breakouts	0.5 ± 1.1	1.1 ± 1.8	46.0 (0.758)	0.164 (small)
Bloating	0.7 ± 1.7	1.1 ± 1.7	47.0 (0.762)	0.146 (small)
Back pain	1.4 ± 1.5	1.2 ± 2.2	41.5 (0.170)	0.246 (small)
Nausea	0.5 ± 0.8	0.1 ± 0.2	40.0 (0.086)	0.273 (small)
Fatigue	0.4 ± 0.7	0.6 ± 1.2	53.5 (0.467)	0.027 (small)
Mood swings*	0.7 ± 1.4	0.03 ± 0.08	33.0 (0.029)	0.400 (moderate)
Stressed	0.6 ± 1.0	0.7 ± 1.5	50.0 (0.358)	0.091 (small)
Tenderness	0.6 ± 1.5	0.5 ± 1.2	52.0 (0.407)	0.055 (small)

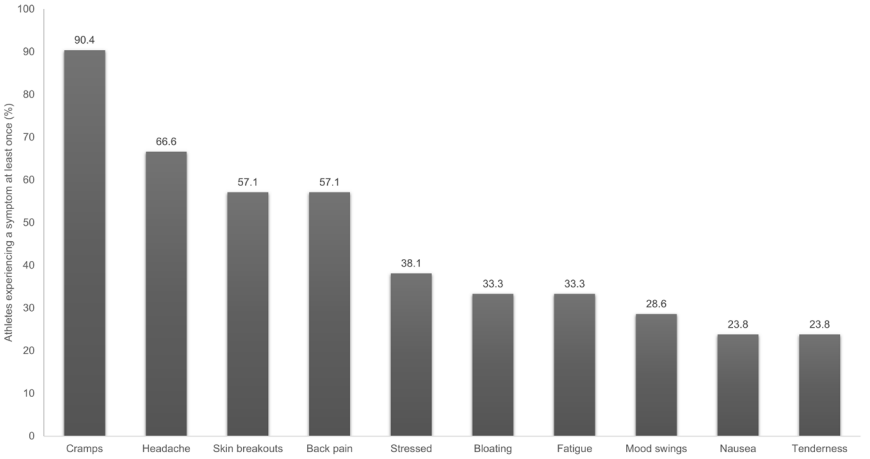

Figure 1: The prevalence of symptoms reported at least once by an athlete during the observed time period.

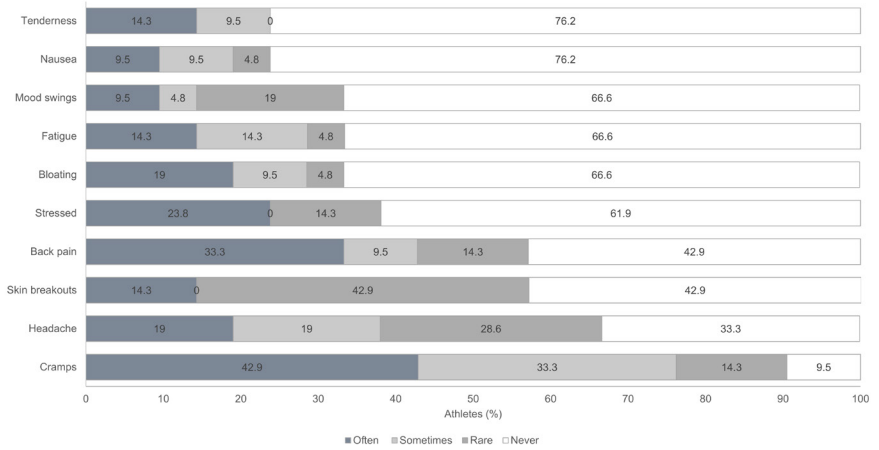

Figure 2: The percentage of athletes reporting symptoms in the frequency categories of often, sometimes, rarely, and never

DISCUSSION

This study aimed to quantify the frequency of MC symptoms experienced by Division I female lacrosse athletes and to discover whether the symptoms were different among those who were taking HCs versus those who were not. Approximately 95% of the athletes experienced symptoms of some form in relation to their menses or withdrawal bleed. This aligns with previous literature indicating that 90% of women from the general female population experience symptoms associated with menses (Mauvais-Jarvis, Clegg, & Hevener, 2013). Cramps, headaches, skin breakouts, and back pain were among the most frequently noted symptoms, and tenderness and nausea were seen least frequently. Cramps occurred in each cycle for 43% of the athletes, and only 9.5% of the athletes did not experience cramps during the four-month observation period. Mood swings were mostly experienced by HC users, with two athletes experiencing them often, one experiencing them sometimes, and four experiencing them rarely. The one non-HC user who experienced mood swings indicated it as a symptom that only occurred rarely. These findings support current research indicating that both HC users and non-users experience negative symptoms related to withdrawal bleeds and menstruation, respectively (McKay et al., 2024; Oxfeldt, Dalgaard, Jørgensen, & Hansen, 2020; Parker, Elliott-Sale, Hannon, Morton, & Close, 2022; Roffler et al., 2024). However, the specific differences in symptoms experienced by both groups vary across the studies (McKay et al., 2024; Oxfeldt et al., 2020; Parker et al., 2022).

Of the ten symptoms included in this study, only mood swings showed a difference between HC and non-HC users. The other nine symptoms were not different between groups, and all had small or trivial effect sizes. Estrogen has been shown to be neuroprotective and modulate neurotransmitters like serotonin and dopamine, while progesterone has a negative effect on mood through pathways that ultimately reduce serotonin (Mu & Kulkarni, 2022). The link between HC use and mood remains controversial, but it is believed that the amount and type of progesterone in the HC probably negatively affect the serotonin levels (Mu & Kulkarni, 2022). Previous literature has reported that non-HC users have a greater frequency of acne and skin-related issues with no other difference between the groups (McKay et al., 2024). McKay et al. (2024) reported that a higher percentage of non-HC users experienced mood swings (13.7%) compared to HC users (5.4%), but this was not statistically different. In a large cross-sectional study, Martin et al. (2018) showed that HC users and non-HC users experienced mood swings at approximately the same rate, 4.2% and 4.1%, respectively. Bruinvels et al. (2021) reported that mood changes

were the most frequently reported symptom (90.6%) of non-HC users. The participants included exercising women from seven countries, but they were not specifically athletes participating in competition. Furthermore, the study was conducted via a cross-sectional survey. Future studies should include both HC and non-HC users with prospective data collection, as there are very few in the current literature. Prospective studies also improve the accuracy of symptom reporting.

Overall, 100% of athletes studied have experienced negative symptoms associated with the MC (Oester et al., 2024), which may be useful information to incorporate into athlete preparticipation examinations (Schulz et al., 2024). Martin et al. (2018) surveyed participants about both negative and positive aspects of the MC and found that many HC users positively viewed having regular periods, the cessation of or less frequent periods, and reduced bleeding. The present study focused only on the negative side effects of menses and withdrawal bleeding. Cramps were the most frequently cited symptom in the present study, regardless of HC use, aligning with previous literature about various sports (Brown et al., 2021; Bruinvels et al., 2021; Martin et al., 2018; Roffler et al., 2024). The high frequency of headaches (Martin et al., 2018; McKay et al., 2024; Roffler et al., 2024), skin breakouts (Martin et al., 2018; McKay et al., 2024), and back pain (Martin et al., 2018; McKay et al., 2024) are also regularly reported in the literature. However, other symptoms such as fatigue/disturbed sleep and weight gain have also been reported with high frequency (Martin et al., 2018; Roffler et al., 2024). The present study did not inquire about either of these symptoms as a negative effect of the MC. However, Marchelli et al. (2025) found that athletes from a similar population reported no differences in sleep quality or duration during menses or by HC use.

Previous literature has only used the MSi for non-HC users, and the traditional MSi includes 18 variables for a high score of 54 (Bruinvels et al., 2021; Roffler et al., 2024). The present study only included ten symptoms; thus, comparisons can only be made with frequencies and not with an overall MSi score. The present study reported that 90.5% of the participants experienced cramps compared to 100% of the participants in Roffler et al. (2024) and 80% of the participants in Bruinvels et al. (2021). Between the three studies, 30-47% of the participants report experiencing cramps often. Notably, Bruinvels et al. (2021) reported the low-end range from a large-scale cross-sectional analysis of older female exercisers (38.3 ± 8.7 years) who were not taking HCs. Whereas the present study and Roffler et al. (2024) showed a higher percentage experiencing cramps and collected data for each MC in their younger competitive athletes (18 to 27.7 years) and included some HC users. All three studies

indicated that approximately 20% of the participants experienced headaches often, but Bruinvels et al. (2021) indicated that 70% of their participants experienced them at any frequency, and both Roffler (2024) and the present study ranged from 60-67% of the athletes. Fatigue was the third and fourth most frequently reported symptom for Roffler et al. (2024) and Bruinvels et al. (2021), respectively, but ranked seventh in the present study. The percentage of athletes reporting fatigue often and sometimes was similar in the present study and Roffler et al. (2024) (13-14%), but 35% of the participants in the Bruinvels study (2021) cited fatigue as occurring often. It is difficult to ascertain the reason for these differences, but prospective studies evaluating each MC provide more reliable data than the cross-sectional information presented by Bruinvels (2021). Further, differences may exist between the studies due to the age differences noted and comparisons between competitive athletes and recreational exercisers. Future research should consider these components to provide more robust comparisons between groups.

Limitations of the present study include evaluating only one team, limited comparisons with the MSi, only collecting symptoms on the days of reported menstruation and withdrawal bleed, and variations of the HCs used in the participants. Women experience symptoms outside of menses and future research should consider collecting each day that women experience any MC-related symptoms (McKay et al., 2024). We also did not ask the athletes if they thought their performance was affected by their MC symptoms, and this would be a valid question to include as 51-93% of athletes indicate that they perceive a negative effect of their symptoms on their performance (Bruinvels et al., 2021; Findlay et al., 2020; Martin et al., 2018). The self-report survey used in the present study is an accepted athlete monitoring tool, but it has not been assessed for validity and reliability. The present study also did not inquire how training or performance affected their MC symptoms, positively or negatively. There is evidence that some exercise may reduce menstrual discomfort (Kannan, Chapple, Miller, Claydon, & Baxter, 2015; Vaghela, Mishra, Sheth, & Dani, 2019) and further investigation is warranted. We also did not control whether non-HC users had used HCs prior to the study. This study also had a small n-size for group comparisons. While the variation in HC use in this study reduces the internal validity of the work, the study does have strong external validity for many female teams. Teams typically consist of women using a variety of HCs, including those using none, and must still be expected to coordinate training and deliver high performance in games. The present study provides practical use for this information when collecting these data with team athletes.

CONCLUSIONS

There is wide variation in the frequency of MC-related symptoms that athletes experience. Tracking symptoms associated with MC can help athletes and coaches be aware of patterns and incorporate methods for mitigating or alleviating the symptoms. Symptom tracking can also help athletes mentally prepare for the effects of their MC on training and performance. Tracking may also assist with communication of discomfort and fatigue between athletes and coaches. Providing education to athletes and coaches about the physiological effects of the MC and the use of different HCs would also be beneficial. Understanding individual responses to the MC and HC use can help coaches plan training and workload. Further research is needed to help determine the most prudent strategies for tracking and pattern recognition, to determine appropriate intervention strategies, and to include a large and diverse population. These data indicate that athletes who experience menses or withdrawal bleeds are very likely to have symptoms associated with this event, regardless of HC use. HC users experiencing a high frequency of certain symptoms should speak with their healthcare provider and consider alternatives to their HC.

Author Contributions

JAB conceptualized the study, participated in the study design, data collection, data analysis, and manuscript writing. MG and HH conceptualized the study, participated in the study design, and edited the manuscript.

Competing Interests

The authors declare that they have no competing interests.

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PHYSICAL ACTIVITY AND SCREEN TIME IN PRESCHOOL CHILDREN IN CROATIA

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ABSTRACT

This research investigates how disparities in physical activity and screen time among preschoolers can be influenced by parental education and involvement, as well as the involvement of the extended family in child-rearing. The study involved 231 parents who provided information about their children from the three (out of four) regions in Croatia. The analysis revealed statistically significant differences in children's screen time based on the parents' educational level ($p<0.000$) and involvement in joint physical activity ($p<0.000$). No differences were found in the children's screen time or physical activity depending on the involvement of extended family members (grandparents). Less screen time does not automatically mean higher levels of physical activity in preschool children. It is essential to determine the factors that influence physical activity in preschool children and the time they spend in front of screens.

Keywords: *preschool children, family, screen time, children's physical activity*

TELESNA DEJAVNOST IN ČAS PRED ZASLONI PREDŠOLSKIH OTROK NA HRVAŠKEM

IZVLEČEK

Raziskava preučuje, kako na razlike v telesni dejavnosti in času pred zasloni pri predšolskih otrocih vplivajo izobrazba in vključenost njihovih staršev ter vključenost razširjene družine v vzgojo otrok. Zajela je 231 staršev iz treh (od štirih) hrvaških regij, ki so posredovali podatke o svojih otrocih. Analiza je pokazala statistično značilne razlike v času pred zasloni glede na izobrazbo staršev ($p<0,000$) in vključenost staršev v skupne telesne dejavnosti ($p<0,000$). V zvezi z vključenostjo razširjene družine (starih staršev) raziskava ni pokazala razlik glede časa pred zasloni ali telesne dejavnosti otrok. Manj časa pred zasloni pri predšolskih otrocih ne pomeni nujno več telesne dejavnosti. Ključno je prepoznati dejavnike, ki vplivajo na telesno dejavnost predšolskih otrok in na čas, ki ga preživijo pred zasloni.

Ključne besede: *predšolski otroci, družina, čas pred zaslonom, telesna dejavnost otrok*

INTRODUCTION

Physical activity (PA) is beneficial for maintaining and enhancing health (Hawlader et al., 2023; Chen et al., 2024) and influences the proper growth and development of children (Sterdt, Liersch & Walter, 2014; Bingham et al., 2016; Zeng et al., 2017; Piercy et al., 2018). Although promoting a healthy lifestyle is particularly crucial during early childhood (Jones, Hinkley, Okely & Salmon, 2013; Hinkley, Brown, Carson & Teychenne, 2018; Tran et al., 2025), children are becoming increasingly less physically active (Sobchuk, Connolly & Sheehan, 2019; Husu et al., 2024; Phipps et al., 2024). Lifestyles are changing and modern parenting involves greater supervision of children (Holt et al., 2016; Day, 2024). Unstructured, free active play outdoors is declining, despite its importance for child development (Holt et al., 2016; Bento & Dias, 2017; Sobchuk et al., 2019; Dankiw, Tsiros, Baldock & Kumar, 2020; Lee, Shih & Tremblay, 2024; Lee, Flouri & Jackson, 2025). For preschool-aged children, free outdoor play is the most natural way to engage in PA and is critical for promoting healthy development (Caroli et al., 2011; Bento & Dias, 2017).

Still, participation in structured sports activities is often promoted among children, which can pose an additional burden for parents (Day, 2024). The demands of employment may prevent parents from providing consistent support for their children's PA (Balkó, Balkó, Valter & Jelínek, 2017). For some children, daily routines include time spent in kindergarten, and grandparents are also often involved in childcare (Budden et al., 2024; Hu et al., 2023). Simultaneously, technology is highly accessible to children (Sharkins, Newton, Albaiz & Ernest, 2016). While society promotes the importance of screen use (Määttä et al., 2017), the development and accessibility of technology provide endless entertainment opportunities (Schmidt-Persson et al., 2024). Additionally, some parents use screens for educational and parenting purposes (Griffith, 2023) and the term "digital babysitter" is becoming increasingly common (Rhodes, 2017; Lev & Elias, 2020).

Consequently, physical inactivity is increasing across all domains (Pišot, 2022). The number of children with weight issues (Bentham, Di Cesare, Bllano & Boddy, 2017; Jin, Zhou & Chen, 2025), type 2 diabetes mellitus (Temneanu, Trandafir & Purcarea, 2016; Serbis, Giapros, Kotanidou, Galli-Tsinopoulou & Siomou, 2021), poor posture (Balkó et al., 2017), mental health problems (Liang et al., 2024; Schmidt-Persson et al., 2024) and other issues is growing.

Various factors influence children's PA and screen time (ST). Increasing attention is being paid to the socio-ecological model, which considers a child's individuality, as well as societal and environmental influences on PA and

sedentary behaviour (SB) (Bronfenbrenner, 1995; Crawford et al., 2010; Lopes, Rodrigues, Maia & Malina, 2011; Paudel, Marshall, Veitch, Paudel & Hesketh, 2025). Accordingly, the aim of this study is to examine differences in PA and ST among preschool children, which can be attributed to different levels of parental education and the participation of parents and the wider family in upbringing.

METHODS

The research was anonymous and conducted in 2022 in Croatia, encompassing three of the country's four statistical regions (City of Zagreb, Pannonian and Northern Croatia) using a snowball sampling method on a randomly selected sample. The questionnaire included four questions related to descriptive data (the gender and age of the children, parental education level and the county of residence) and two questions related to the involvement of the immediate (parents) and extended family (grandparents) in joint physical activities with children, using a Likert scale (ranging from occasionally to often).

To assess the children's physical (kinesiological) activity, the Netherlands Physical Activity Questionnaire (NPAQ) was used (Janz, Broffitt & Levy, 2005). The first 7 questions are answered using a Likert scale (range 1 to 5). The result is the average of the entered responses. Higher values indicate higher amounts of children's PA.

The eighth question in this questionnaire is open-ended and pertains to the time children spend using screens.

The study posed the following hypotheses:

H1: There are differences in children's PA and ST depending on the parental education level.

H2: There are differences in children's PA and ST depending on the frequency of parental participation in joint physical activities.

H3: There are differences in children's PA and ST depending on the frequency of grandparental participation in joint physical activities.

The study included 231 parents who provided data for their children (51.9% girls (N=120) and 48.1% boys (N=111)), aged between 2 and 7 years (M=5.07±1.36).

Depending on the statistical needs of the hypotheses, the children were assigned to different categories. For the analysis of the first hypothesis, the sample was divided based on parental education level. Of the participants, 64.9%

(N=150) had parents with tertiary education (university degree) and 35.1% (N=81) had parents with secondary education (high school degree).

For the second hypothesis, children were divided based on the frequency of parental participation in joint physical activities. Parental activities with children were infrequent in 58.4% (N=135) and frequent in 41.6% (N=96) of cases.

For the third hypothesis, children were divided based on the frequency of grandparental participation in physical activities. Grandparents' activities with children were infrequent in 73.2% (N=169) and frequent in 26.8% (N=62) of cases.

For statistical data processing, we used IBM SPSS Statistics 19.0. To examine the data distribution, the Kolmogorov-Smirnov test was employed. Because the distribution of the results was non-normal, we used the Mann-Whitney U for group comparisons. Hypotheses were accepted at $p<0.05$.

RESULTS

Most respondents reside in Pannonian Croatia (41.6%, N=96), followed by the City of Zagreb (35.1%, N=81) and Northern Croatia (23.4%, N=54).

The age range of the children participating in the study was from 2 to 7 years (M=5.07, ±1.36), with 70 (30.3%) children aged 2–4 years and 161 (69.7%) aged 5–7 years. The average PA level of the children, as assessed using the NPAQ, was 3.75 (range 1.29–5, ±0.66). The parents reported that children aged 5–7 years were slightly more physically active (M=3.77, ±0.67) than children aged 2–4 years (M=3.70, ±0.63).

Children aged 2–4 years spent an average of 69.07 min/day in front of screens (range 0–210 min/day, ±44.46, N=70), while children aged 5–7 years spent 79.32 min/day (range 0–240 min/day, ±44.06, N=161). The average ST for all the children was 76.21 min/day, ±44.34.

Parental involvement in joint physical activities with children had an average score of M=3.24 (range 1–5, ±0.92), while the involvement of grandparents averaged M=2.72 (range 1–5, ±1.12).

The results indicate no statistically significant difference in the children's PA ($Z=-0.075$, $p>0.941$) based on parental education level (Table 1). The children of parents with tertiary education were no more physically active than the children of parents with secondary education (M=3.75±0.61, N=150 vs. M=3.74±0.75, N=81). However, a statistically significant difference was found in ST ($Z=-3.83$, $p<0.000$), with the children of parents with tertiary education spending less time in front of screens compared to those of parents with

Table 1. Descriptive Statistics and Mann-Whitney U Test Results for Physical Activity and Screen Time by Parental Education and Coactivity with Parents and Grandparents

Variables	Grouping variable		N	Mean	SD	Mann-Whitney U	Z	p
PA	Parental education	secondary	81	3.74	0.75	6039.00	-0.075	0.941
		tertiary	150	3.75	0.61			
ST	Parental education	secondary	81	91.67	46.54	4268.50	-3.825	0.000*
		tertiary	150	67.87	40.89			
PA	Parent-child coactivity	less frequently	135	3.71	0.66	5777.50	-1.408	0.159
		more frequently	96	3.81	0.65			
ST	Parent-child coactivity	less frequently	135	83.93	43.26	4724.00	-3.600	0.000*
		more frequently	96	65.35	43.77			
PA	Grandparents-child coactivity	less frequently	169	3.75	0.66	5192.50	-0.104	0,917
		more frequently	62	3.74	0.66			
ST	Grandparents-child coactivity	less frequently	169	75.66	43.51	5170.50	-0.156	0.876
		more frequently	62	77.73	46.87			

Legend: N – number of participants; SD – standard deviation; Z – standardised value from Mann-Whitney U test; PA – Physical activity; ST – Screen time (min/day); *p < 0.05

secondary education (M=67.87±40.89, N=150 vs. M=91.67±46.54, N=81) (Table 1). Therefore, hypothesis 1 is partially supported.

There was no statistically significant difference in the children's PA (Z=-1.408, p>0.159) based on the frequency of parental participation in joint physical activities (Table 1). Children whose parents participated more frequently were no more physically active than those whose parents participated less frequently (M=3.81±0.65, N=96 vs. M=3.71±0.66, N=135). However, a statistically significant difference was found in ST (Z=-3.600, p<0.000), (Table 1). Children whose parents participated more frequently in joint physical activities spent less time in front of screens compared to those whose parents participated less frequently (M=65.35±43.77, N=96 vs. M=83.93±43.26, N=135). Therefore, hypothesis 2 is partially supported.

There were no significant statistical differences in the children's PA (Z=– 0.104, p>0.917) based on the frequency of their grandparents' participation in joint physical activities (Table 1). Children whose grandparents participated more frequently were equally active compared to those whose grandparents participated less frequently (M=3.74±0.66, N=62 vs. M=3.75±0.66, N=169). Similarly, no significant difference was observed in ST (Z=-0.156, p>0.876), (Table 1). Children whose grandparents were more frequently involved spent a similar amount of time in front of screens compared to children whose grandparents participated less frequently (M=77.73±46.87, N=62 vs. M=75.66±43.51, N=169). Therefore, hypothesis 3 is not supported.

DISCUSSION

Based on parental self-reports using the NPAQ, the mean score was 3.75 (out of 5), with older children showing slightly higher levels of PA than younger ones (3.77 vs 3.70). Given the high NPAQ scores obtained, we conclude that the children who participated in the study tend to be physically active. However, numerous studies show that preschool children are not sufficiently physically active (Matarma et al., 2017; Arts et al., 2023). Self-assessment using questionnaires is the most common method of assessing PA (Sallis & Saelens, 2000), with the possibility of bias (Warnecke, 1997; Ghanamah, 2025; Jin et al., 2025). ST is most commonly measured by the parents' self-reports of the amount of time their child spends on screens throughout a typical day (Barr et al., 2020). However, this method is imprecise (Barr et al., 2020). Thus, careful interpretation of the results is recommended. According to the World Health Organisation (2019), children between the ages of 2 and 4 should use

screens for no more than 60 min/day. Our results show that children aged 2-4 years exceed the recommendations, using screens for an average of 69.07 min/day (range 0-210 min/day). Daily screen exposure for children aged 5 and older should not exceed 120 min/day (Tremblay et al., 2014). The average ST in this age group in our study is 79.32 min/day (range 0-240 min/day), indicating that the recommendations are generally being followed. It is concerning that some preschool children use screens for up to 240 min/day. Previous research in Croatia (Rogović, Šalaj & Puharić, 2022) and worldwide (Määttä et al., 2017; Ma, Li & Chen, 2022; Carballo-Fazanes, Díaz-Pereira, Fernández-Villarino, Abelairas-Gómez & Rey, 2023) show that the average ST regularly exceeds the recommended values. Extended interaction with digital screens can have detrimental implications for children's development (Lin, Cherng, Chen, Chen & Yang, 2015) and social competencies (Ma et al., 2022). Despite the necessity of monitoring children's screen usage (Ma et al., 2022), findings from a study in Australia revealed that 50% of young and preschool children use screens without supervision (Rhodes, 2017).

Our study does not show a difference in the children's PA with respect to parental education, which is confirmed by some other studies (Kippe & Lagestad, 2018). It is possible that the lack of a significant correlation between the children's PA and parental education is influenced by the relatively homogeneous sample of parents in terms of socioeconomic status and access to PA opportunities or similar early care and education programmes (similar PA and outdoor play standards), which limits variation based on education level. Furthermore, parents across different educational levels may have similar perceptions of their child's activity.

It is important to recognise that when self-assessing PA, inaccurate perception (overestimation or underestimation) of the activities performed is possible (Medina, Jáuregui, Hernández, Shamah, & Barquera, 2021). Warnecke (1997) found that individuals exaggerate their participation in PA due to social acceptance. Recent findings indicate that parents are not sufficiently familiar with the established guidelines for recommended ST and PA for children (Csima, Podráczky, Keresztes, Soós, & Finánczc, 2024), potentially contributing to misperceptions and assessments related to these behaviours.

Our analysis did not consider whether the relationship between parental education and outcomes is moderated by the gender of the child and/or parents. Thus, Ré et al. (2025) found that sons of highly educated mothers were less physically active, since they played with a ball less in their free time. In this study, playing with a ball proved to be an important item for meeting the recommendations regarding children's PA. Furthermore, Güven, Dönmez,

İncedere and Taşar (2025) found that higher parental health literacy was greater among highly educated parents and it was associated with the more frequent participation of children in sports activities. Other studies have also found that children of highly educated parents are more physically active (Dawson-Hahn, Fesinmeyer & Mendoza, 2015; Lampinen et al., 2017; Muñoz-Galiano, Connor, Gómez-Ruano & Torres-Luque, 2020; Vorlíček et al., 2025). Conversely, Vale et al. (2014) found that more than half of the children of highly educated parents do not meet the recommendations for PA. Some parents believe that it is important to engage in joint activities, but they do not prioritise PA over some sedentary activities, including joint ST (Thompson et al., 2010). Parents cite various factors, such as a fast-paced lifestyle, adverse weather conditions and unfavourable socioeconomic status, among others (Thompson et al., 2010). We believe that highly educated parents prioritise intellectual activities over physical ones and emphasise their children's academic success. It is also possible that these children participate in additional activities during their free time that further promote academic success. Thus, academic and sports activities replace children's free play (Bento & Dias, 2017). However, numerous other factors can also influence children's PA, such as parental attitudes (Tandon, Saelens & Copeland, 2017), parental stress (Maher et al., 2017), adequate family functioning (Loprinzi, 2015), etc.

Our study found that the children of highly educated parents spend less time in front of screens, which aligns with the findings from several previous research projects (Carson & Janssen, 2012; Lin et al., 2015; Määttä et al., 2017; Burnett et al., 2023). More educated parents tend to be more effective in organising their children's leisure time, ensuring a balance between PA and SB (Muñoz-Galiano et al., 2020). In addition, during sedentary time, various quiet activities can be conducted without the use of media, such as reading, drawing, driving, dining, etc. (Aubert et al., 2022; Chaput et al., 2020). The study by Lampinen et al. (2017) identified a gender-specific trend, where lower parental education was associated with more sedentary behaviour from screen use in boys only. Parents with lower educational attainment may see screen use in early childhood as beneficial for future educational and career success (Määttä et al., 2017). However, LeBlanc et al. (2015) found that, overall, children whose fathers have more than a high school education spend more time in sedentary activities and using screens. When analysed by gender, this pattern is only evident among daughters, not sons (LeBlanc et al., 2015).

Our results show no statistically significant difference in the children's PA concerning the frequency of parental participation in joint PA (coactivity), such as walking together, playing, going to the park, etc. Several explanations are

possible for these results. There is a possible discrepancy between the parents' perceptions and the children's actual behaviour, because the study was conducted using questionnaires, not accelerometers. There is also a possible discrepancy between the parents' perception of joint activity and their actual coactivity with children. It is possible that they overestimate (accidentally or intentionally) the amount of time they spend in coactivity with children. Such uncertainties could be avoided in future research by using accelerometry for both parents and children. We emphasise that the type of PA that parents engage in with their children may vary, so not all shared PA is high-intensity. It is possible that parents, due to a lack of knowledge, do not take into account low-intensity PA achieved during the day when assessing their children's PA. Low-intensity PA is the primary activity level of preschool children, especially girls (Berglind & Tynelius, 2018). We can also ask the following question: Are parents physically active enough? Research indicates that many parents fall short and do not meet the PA recommendations (Guthold, Stevens, Riley & Bull, 2018; WHO, 2020; Bueno et al., 2025). This raises the question of whether parents who may not be active enough themselves can accurately assess physical coactivity with their children. It is possible that some parents have a more sedentary lifestyle, which is then reflected in the adoption of similar habits in their children (developing habits related to SB and physical inactivity). The PA levels and sedentary patterns of children are considerably affected by the example set by their parents (Keyes & Willson, 2021), which has an important influence on their behaviour (Maia, Braz, Fernandes, Sarmento &Machado-Rodrigues, 2025; Paudel et al., 2025). In addition, some children naturally prefer sedentary activities (Andersen et al., 2017). Therefore, it is possible that parents with calmer children encourage them to be more active through joint PA. One possible reason is that children who engage in PA with their parents are more tired and spend less time playing active games in their free time, unlike those who participate in such activities with their parents less often. There is evidence suggesting that children who spend more time outside are more physically active (Sterdt et al., 2014; Hinkley et al., 2018). Parents can take their children to the park, but without other children to play with, the child may not engage in active play. Matarma et al. (2017) found that maternal-child coactivity increases the children's PA levels. Other authors have found that parent-child coactivity influences the likelihood of meeting the recommendations for children's PA (Pyper, Harrington & Manson, 2016; Uijtdewilligen et al., 2017; Hnatiuk, Dwyer, George & Bennie, 2020) and improves communication (Thompson et al., 2010). Bingham et al. (2016) found a positive correlation between the amount of time children spend playing with their parents and their overall

PA levels. Parent-child coactivity is more significant at a younger age than in the period closer to adolescence (Rhodes et al., 2015). Various neighbourhood factors, including parks (Greer, Castrogivanni & Marcello, 2017; Hunter, Leatherdale, Spence & Carson, 2022), and parental stress (Maher et al., 2017) are crucial in coactivity. Thompson et al. (2010) found that the majority of parents believe that joint family PA is important, but despite this, they rarely engage in it. Of all forms of parental behaviour in terms of supporting children's involvement in PA, coactivity is the rarest (as much as 80.5% of parents do not participate in joint PA with their children), (Pyper et al., 2016) and 58.4% in our study. Interventions that encourage parent-child coactivity are justified and very useful (Rhodes & Lim, 2018; Grant et al., 2020). While Rhodes & Lim (2018) consider such interventions to be unsuccessful, a study conducted by Ha, He, Lubans, Chan and Ng (2022) found that coactivity between children and parents increased after an online intervention, namely parent education on so-called physical literacy.

Our research indicates that children with parents who often participate in co-activities tend to spend less time on screens compared to those whose parents are less involved in such activities. Although joint ST can promote positive family relationships, it is necessary to replace this time with some joint family activities that are important for the children's health (Pyper et al., 2016).

There was no identified difference in the children's PA or screen usage associated with the co-activities of grandparents and grandchildren in this study. Parental care for preschool children differs from that of grandparents and is superior in developing fundamental motor skills (Hu et al., 2023). Grandparents often have limited participation in PA with their grandchildren due to age, illness and/or injury, finances and the availability of playgrounds in the neighbourhood (Budden et al., 2024), which contributes to screen use (Jongenelis et al., 2024) increased sedentary activities and reduced moderate PA (Lu, Shen, Huang & Corpeleijn, 2022). Support, the availability of parks/playgrounds in the neighbourhood and play equipment positively influence the PA of grandchildren (Jongenelis et al., 2024).

We believe that parents and the extended family are key contributors to shaping healthy habits, including PA and ST. However, in our study, physical coactivity between parents/grandparents and children did not prove to be a significant factor influencing children's PA. To gain a better understanding of this issue, future research should examine how parents/grandparents and children engage in physical coactivity, examining the type of activity or play, the location (indoors or outdoors), duration, frequency and other relevant factors.

PA and ST result from complex interactions of numerous socio-ecological factors. Parental influence is multifactorial (support, encouragement, motivation, parental PA, etc.), (Rhodes et al., 2015; Pyper et al., 2016; Garriguet, Bushnik & Colley, 2017; Arts et al., 2023) and is more dominant than the influence of grandparents (Hu et al., 2023). Opportunities for PA at home (Dowda et al., 2011), attending kindergarten (Pate, Pfeiffer, Trost, Ziegler & Dowda, 2004; Dowda et al., 2011; Matarma et al., 2017; Kippe & Lagestad, 2018), siblings (Matarma et al., 2017; Schmutz et al., 2017), place of residence, the proximity and availability of parks/playgrounds, neighbourhood safety, play equipment (Terrón-Pérez, Molina-García, Martínez-Bello & Queralt, 2021; Huang, Luo & Chen, 2022; Lu et al., 2022), playground size, and the availability of sports equipment (Arts et al., 2023) are also some factors that contribute to children being more physically active. Attending kindergarten can affect children's PA (Sigmundová et al., 2016; Matarma et al., 2017; Kippe & Lagestad, 2018) more than family factors (Huang et al., 2022). Individual characteristics of the child, such as gender, often determine higher levels of PA (Pate et al., 2004; Schmutz et al., 2017; Sterdt et al., 2014), temperament (Schmutz et al., 2017), the child's inclination towards PA (Sterdt et al., 2014), the child's enjoyment of PA (Dowda et al., 2011), motor competencies (Robinson et al., 2015; Carballo-Fazanes et al., 2023), etc.

SB includes various activities that can have a complex relationship with health (Aubert et al., 2022). While reading and calm activities are advantageous for cognitive growth, it is not known that ST has health or developmental benefits for young children (Downing, Hnatiuk & Hesketh, 2015). Despite this, SB related to screen use increases at the expense of PA, even among preschool children (Dawson-Hahn et al., 2015). Consequently, children who devote more time to screen use are less likely to engage in PA (Dawson-Hahn et al., 2015; del Pozo-Cruz et al., 2019), which may negatively affect their health. Setting rules, monitoring time, using screens with the child, having meals without screens and encouraging the child to engage in activities can influence ST (Xu, Wen & Rissel, 2015).

Most parents believe that the recommendations regarding children's PA and ST are difficult to meet (Hamilton, Hatzis, Kavanagh & White, 2015), while some parents are not informed about the guidelines (Csima et al., 2024). Due to globalisation and technological development, children are deprived of free play (Bento & Dias, 2017). The study by Tandon et al. (2017) found that some parents associate outdoor play in colder conditions with a risk of illness, and a portion of them prefer their children not to play outside at all. Consequently, empowering parents to manage their children's screen use and foster outdoor PA is essential.

Some countries implement various educational programmes to train educators (Tran et al., 2025) and parents (Ha et al., 2022; Paudel et al., 2025) in leading a healthy lifestyle, as well as interventions that aim to promote PA in children while reducing SB and ST (Yoong et al., 2020). Some interventions are aimed at the entire family (Phipps et al., 2024). Some strategies include educational interventions for parents on the importance of coactivity between parents and children (Ha et al., 2022), as well as other family members who participate in childcare, then developing and strengthening parental awareness of exercise (Song & Ge, 2025), empowering the parents in forming correct views on health awareness and related behaviours (Vrijkotte, Varkevisser, van Schalkwijk & Hartman, 2020). According to Song & Ge (2025), greater parental awareness of PA correlates with greater PA in children. According to Loprinzi (2015), understanding the underlying factors that impact these behaviours is a necessary foundation for creating, applying and evaluating interventions aimed at encouraging PA and limiting sedentary habits in children. Parental awareness of their role in shaping their children's PA is crucial for the creation of effective intervention strategies (Song & Ge, 2025). Based on this, we present some basic suggestions regarding PA and SB for preschool children.

The basic recommendations regarding PA for preschool children are as follows: children aged 1-2 years: a minimum of 180 min of total daily PA; 3-4 years: at least 180 minutes daily as well, with a minimum of 60 min at moderate to vigorous intensity (Jurakić & Pedešić, 2019; WHO, 2019); children aged 5-17 years: an average of 60 min/day of moderate to vigorous PA (Jurakić & Pedešić, 2019; WHO, 2020). Parents also need to be informed about the reasons why children should play outside (Bento & Dias, 2017).

The basic recommendations for ST are as follows: children < 2 years: no ST is recommended; children 2-4 years: 60 min/day (Jurakić & Pedešić, 2019; WHO, 2019); children 5 years and older: 120 min/day (Jurakić & Pedešić, 2019).

We also believe that it is necessary to implement educational interventions aimed at parents, families and kindergarten teachers, providing information on recommendations for children's PA, SB and ST; increase awareness about the negative consequences of physical inactivity and prolonged ST in childhood; increase health literacy; promote coactivity between parents and children and other family members, and free unstructured outdoor play; empower families/teachers to foster physically active lifestyles and stimulate active play in children.

We believe that additional research should be conducted to more precisely determine the various socio-ecological factors (which may also be culturally

conditioned) that influence PA, SB and ST in children in Croatia, which would more precisely target the goals of strategic measures.

Conducting longitudinal studies covering the entire territory of Croatia would allow monitoring changes in children's PA and SB over time, as well as the influence of parents, extended family members and kindergarten teachers. Such designs would allow the identification of cause-and-effect relationships and developmental patterns that cannot be captured by cross-sectional approaches. Furthermore, future research should consider using mixed-method designs, combining objective measurements of PA and SB (e.g., accelerometry) with qualitative methods such as interviews or observations. This would contribute to a better understanding of the multifaceted socio-ecological influences on children's behaviour. By integrating different methodological approaches and extending the follow-up period, future studies could better detect dynamic changes across developmental stages and provide stronger evidence for developing and strategically planning interventions.

Encouraging children to move and reduce ST requires a holistic approach (Chen et al., 2022) and teamwork (Bento & Dias, 2017). A combination of strategies targeting the individual, family, kindergarten and policy levels is needed to improve the effectiveness of preventive measures.

In addition, for more precise and objective results, we recommend measuring PA using more reliable methods in future research (Sterdt et al., 2014), such as accelerometry or smartwatches. We also recommend measuring PA simultaneously in both children and parents to obtain more accurate results.

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This study (N = 231) was conducted using a questionnaire, which relied on parental self-reporting. This methodology could introduce biases or recall errors. The use of accelerometry (or smartwatches) would have contributed to greater objectivity in the measurement of children's PA and SB. Furthermore, the study included participants from only three of the four regions of Croatia. Limited geographical coverage, as well as potential cultural, socioeconomic and other regional differences, may have influenced the children's PA and SB. Consequently, the generalizability of the findings is restricted. The children's age range in the study (2 to 7 years) was relatively wide. Although this range primarily includes preschool-aged children, developmental differences within this group could affect PA patterns. Future research should aim to increase the

sample size and extend data collection to all the Croatian regions to enable the more reliable comparisons of results. It would also be beneficial to examine in greater detail the impact of parental education, grandparental involvement and family habits on children's PA and SB. Moreover, future questionnaires should be expanded to assess other relevant socio-ecological factors that may influence children's PA, SB and ST, such as the parents' socioeconomic status, area and region of residence, the parents' health literacy, family routines, type of parent-child coactivity, parental attitudes, environmental influences, environmental characteristics, seasonal variations, climatic conditions, children's gender, a narrower developmental age range, kindergarten impact, etc. For greater generalizability and relevance, it is suggested that future studies incorporate participants from varied age groups, demographics and cultural environments.

CONCLUSIONS

PA and the time children spend using screens are influenced by multifactorial factors. Our research shows that ST is lower in the children of more educated parents and parents who spend more time in joint physical activities with their children. It is important to inform parents and family members about recommendations related to PA and ST and to encourage and empower them to proactively manage their children's free time in order to reduce SB and support healthier development. Parents should define clear rules and boundaries and limit ST. During ST, it is recommended to watch educational content, preferably together with children, and play games less. Parents, grandparents and educators should encourage children to play more actively, especially outdoors. The local community and society in general also play a major role (the accessibility of parks, safety in the neighbourhood, etc.). Various campaigns can also be implemented to educate and raise awareness about the importance of children's movement and the harmfulness of SB and physically inactive behaviour in childhood.

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THE EFFECT OF BOOSTER BREAKS ON NON-SPECIFIC LOW BACK PAIN IN OFFICE WORKERS

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ABSTRACT

Purpose: *Prolonged sitting has a negative effect on office workers, and non-specific low back pain (NSLBP) is one of the most common consequences of an inactive lifestyle and prolonged sitting. Active breaks are a promising intervention to reduce the negative effects of office work.*

Methods: *Forty-two office workers from a Slovenian company were divided into an experimental group (24 office workers who had been taking active breaks for one and a half years) and a control group (N=18, no active breaks). The participants were not randomly allocated to the groups; allocation was based on availability and voluntary participation.*

An online survey was conducted using the Oswestry Disability Index 2.0 (ODI 2.0) and the Visual Analog Scale (VAS). This was a non-randomized, two-arm longitudinal study. Questionnaires were administered once, 1.5 years after the intervention. Statistical analyses were conducted using the Mann-Whitney and Wilcoxon signed--rank tests, with the level of significance set at $p \leq 0.05$.

Results: *The results showed that 81% of office workers had experienced NSLBP at least once in their lives. The ODI 2.0 scores were not significantly lower in the experimental group ($p = 0.155$). However, pain intensity was lower in office workers who took active breaks ($p = 0.001$). All the participants in the experimental group reported that active breaks had a positive effect on their well-being (100%). Furthermore, 37.5% of*

the participants stated that they had become more physically active outside the office as a result of the active breaks.

Conclusion: *Introducing active breaks into the daily routine of office workers is a viable and effective intervention to mitigate the risk of NSLBP. Active breaks offer a comprehensive solution: they not only reduce the negative effects of prolonged sitting, but also reduce stress, improve work efficiency and focus, and promote better moods.*

Keywords: *non-specific low back pain, ergonomics, booster breaks, prolonged sitting, office workers.*

VPLIV AKTIVNIH ODMOROV NA POJAV NESPECIFIČNE BOLEČINE V KRIŽU PRI PISARNIŠKIH DELAVCIH

IZVLEČEK

Cilj: *Dolgotrajno sedenje negativno vpliva na pisarniške delavce, nespecifična bolečina v križu (NBVK) pa je ena najpogostejših posledic neaktivnega načina življenja in dolgotrajnega sedenja. Aktivni odmori so učinkovita intervencija za zmanjšanje negativnih posledic pisarniškega dela.*

Metode: *V raziskavi je sodelovalo 42 pisarniških delavcev podjetja Intra Lighting d. o. o., ki so bili razdeljeni v dve skupini: eksperimentalno (24 pisarniških delavcev, ki že leto in pol izvajajo aktivne odmore) in kontrolno (18 pisarniških delavcev, ki ne izvajajo aktivnih odmorov). Udeleženci niso bili naključno razporejeni v skupine, temveč je razporeditev temeljila na razpoložljivosti in prostovoljni udeležbi. Anketiranje je bilo izvedeno prek spletnega vprašalnika 1Ka, pri čemer smo uporabili Oswestry Disability Index (ODI 2.0) in vidno analogno lestvico (VAL). Študija je bila nerandomizirana longitudinalna študija z dvema skupinama. Vprašalniki so bili izpolnjeni enkrat, leto in pol po intervenciji. Statistične analize so bile izvedene z uporabo Mann–Whitneyjevega in Wilcoxonovega testa, pri čemer je bila raven statistične značilnosti določena na* $p \leq 0{,}05$.

Rezultati: *Rezultati so pokazali, da je 81 % pisarniških delavcev vsaj enkrat v življenju doživelo NBVK. Število točk na lestvici ODI 2.0 pri eksperimentalni skupini ni bilo signifikantno nižje (*$p = 0{,}155$*). Vendar pa se je stopnja bolečine po VAL pri eksperimentalni skupini znižala (*$p = 0{,}001$*). Vse raziskovane osebe v eksperimentalni skupini so potrdile, da so se zaradi aktivnih odmorov bolje splošno počutile (100 %). Poleg tega je 37,5 % anketirancev poročalo, da so zaradi aktivnih odmorov med delom postali bolj telesno dejavni tudi zunaj službe.*

Zaključek: *Uvajanje aktivnih odmorov v dnevno rutino pisarniških delavcev je učinkovita in izvedljiva intervencija za zmanjšanje tveganja za nastanek NBVK. Zato je priporočljivo, da se ta praksa uvede v čim več podjetjih s pisarniškim delom. Aktivni odmori so vsestranska rešitev. Poleg zmanjšanja negativnih posledic dolgotrajnega sedenja, zmanjšujejo tudi stres, izboljšujejo delovno učinkovitost in pozornost in blagodejno vplivajo na splošno počutje.*

Ključne besede: *nespecifična bolečina v križu, ergonomija, aktivni odmori, dolgotrajno sedenje, pisarniški delavci.*

INTRODUCTION

Sedentary office work has a detrimental effect on an individual's physical and mental well-being. Prolonged sitting and extensive computer use significantly contribute to vision impairment, musculoskeletal disorders, headaches, and stress. These symptoms often arise due to poor workplace ergonomics and the nature of office work, which requires extended periods of sitting without sufficient physical activity breaks (Balci & Aghazadeh, 2004). One of the most common health issues among office workers is low back pain (LBP). Within 12 months of employment, between 34% and 51% of office workers experience LBP. This condition affects an individual's well-being, productivity, and overall quality of life. Prolonged static muscle activation while sitting can lead to increased muscle tension, fatigue, soft tissue disorders, and damage to ligaments and intervertebral discs. Additionally, prolonged sitting often causes discomfort in the lumbar region, which often progresses into pain (Waongenngarm, Areerak, & Janwantanakul, 2018).

Non-specific low back pain (NSLBP) refers to LBP without a known specific physical cause. In contrast, LBP can also result from identifiable causes such as radicular syndrome (nerve root compression), trauma, infection, or tumors. NSLBP accounts for 90% of all LBP cases. It is a widespread issue, affecting 60%–90% of the population at least once in their lifetime (Bekkering et al., 2003). Recurrent pain is defined as multiple episodes of LBP within one year, with each episode classified as acute (0–6 weeks), subacute (7–12 weeks), or chronic (lasting more than 12 weeks) (Bekkering et al., 2003). Acute episodes of low-intensity pain are more common, but in some cases, pain persists for months or even years, becoming chronic (Tidy, 2020). In such cases, physiotherapeutic treatment aims to restore the individual's functional capacity to the highest possible level or to the level of physical activity they had before the onset of the NSLBP. The most critical aspect of the treatment is educating patients about the causes and nature of their pain and motivating them to engage in physical activity. Research has demonstrated (Waddell et al., 1997; Van Tulder, Malmivaara, Esmail, & Koes, 2000; Hagen, Hilde, Jamtvedt, & Winemm, 2000) that bed rest is not an effective treatment for acute NSLBP and may even prolong rehabilitation. Instead, remaining physically active during the subacute phase has been shown to accelerate recovery and facilitate an earlier return to work. Furthermore, physically active individuals have a lower risk of developing chronic NSLBP (Bekkering et al., 2003).

Kinesiotherapy is the most effective method for managing NSLBP. Although the optimal type of physical activity has not entirely been established,

muscle-strengthening, stabilization, and flexibility exercises are crucial components of treatment (Bekkering et al., 2003). An effective strategy to reduce both physical (including NSLBP) and psychological issues in the workplace is the appropriate scheduling of work and breaks. Research indicates that frequent short breaks are more beneficial for workers' psycho-physical well-being than fewer, longer breaks. Studies suggest that "micro" breaks every 15 minutes help alleviate muscle tension in the neck, back, and arms, reduce eye strain from computer use, and improve cognitive performance in terms of speed and accuracy. Therefore, frequent short breaks contribute significantly to the overall comfort and efficiency of office workers who rely on computers (Balci & Aghazadeh, 2004).

Additionally, the type of break taken—active or passive—is important. An active break, also known as a "Booster Break", is an organized break designed to enhance physical and mental health. It has been shown to improve the employees' well-being and productivity. An active break typically lasts 10–15 minutes and is led by either a trained employee or an external instructor. It includes stretching exercises for muscles that remain contracted while sitting, and strengthening exercises for muscles that are overstretched in a seated position, as well as breathing exercises. Other forms of active breaks include yoga, Tai Chi, or meditation. Engaging in active breaks can also encourage employees to adopt a healthier lifestyle and become more physically active outside the workplace (Taylor, 2005).

The aim of this study was to examine whether active breaks can reduce the level of NSLBP and/or prevent its occurrence among office workers due to prolonged sitting. Based on the existing literature, we hypothesized that: (1) active breaks will reduce the intensity of NSLBP as measured by the VAS; (2) office workers who engage in active breaks will report more physical activity outside of work; and (3) the experimental group will score better on the ODI 2.0 and VAS compared to the control group.

METHOD

Sample

The sampling method was opportunistic. Data was collected from office workers at Intra Lighting d.o.o., located in Šempeter pri Gorici (Slovenia). The participants were not randomly allocated. The division into groups was based on voluntary participation and accessibility, which may introduce selection

bias. Our study was a non-randomized two-arm longitudinal study, the questionnaires were collected once, after 1.5 years of the intervention. The experimental group consisted of office workers who had been taking 10-minute active breaks twice a week for a year and a half (n = 24). The control group comprised other office workers in the company who had not participated in the active breaks (n = 18). The exclusion criterion was a diagnosed pathology in the lumbar region (not NSLBP).

Intervention

The intervention consisted of 10-minute guided active breaks, conducted twice a week for a duration of one and a half years. The sessions were led by a licensed kinesiologist and included a combination of breathing exercises, stretching of shortened muscles (e.g., hip flexors and chest), strengthening exercises for underactive muscles (e.g., gluteal and core muscles), and posture correction activities. The exercises were designed to address the effects of prolonged sitting and were modified according to the participants' needs. The sessions were performed in the office during working hours and required no special equipment.

The study was conducted in January 2021. A total of 67 respondents completed the online questionnaire, of whom 45 submitted valid responses. Three respondents were diagnosed with specific pathologies in the lower back region (disk herniation, vertebral collapse, and an undisclosed condition) and were excluded from statistical analysis. The final sample consisted of 42 office workers, including 11 women (26%) and 31 men (74%). The average age of the respondents was 39.8 ± 8.6 years, with the youngest being 24 and the oldest 60.

Instruments

The online questionnaire was created using EnKlikAnketa (1KA, Arnes, Slovenia). The questions were designed based on the study's three hypotheses, with the exception of questions 5, 12, and 13. Question 5 represents the Oswestry Disability Index 2.0 (ODI 2.0), while questions 12 and 13 correspond to the Visual Analog Scale (VAS).

Oswestry Disability Index (ODI 2.0)

The ODI 2.0 questionnaire consists of 10 categories of daily activities, with the respondents selecting one answer per category (0–5). The ODI score (index) is calculated using the formula: (total score / total possible score) × 100 = %.

Interpretation of the scores:

- 0%–20%: minimal disability – The patient can cope with most daily activities,
- 21%–40%: moderate disability – Increased pain and difficulty with sitting, lifting, and standing; work and social life may be affected,
- 41%–60%: severe disability – Pain significantly affects daily activities; further investigation is required,
- 61%–80%: crippled – Pain interferes with all aspects of life, requiring intervention,
- 81%–100%: either bed-bound or exaggerating symptoms (Physiopedia, 2021).

The ODI 2.0 questionnaire has been validated and translated into Slovenian and its reliability has been confirmed and its use permitted for this research (Klemenc-Ketiš, 2011). The questionnaire was used to compare NSLBP between employees who participated in active breaks and those who did not.

Visual Analog Scale (VAS)

The Visual Analog Scale (VAS) was used to assess self-reported pain intensity. The participants were asked to indicate their current level of low back pain on a 10-point horizontal line, where 0 represents “no pain” and 10 represents the “worst imaginable pain.” The score was measured in centimeters from the left end of the line. The participants completed this assessment independently online as part of the survey. VAS is a widely used tool for self-assessing pain intensity (Jakovljević & Puh, 2014). This study used the VAS results to compare NSLBP intensity in the experimental group before and after participating in active breaks for a year and a half.

Assessment of Physical Activity

Self-reported physical activity was assessed using multiple-choice questions included in the online questionnaire. The questions (except for questions 5, 12, and 13) inquired about the frequency, duration, and type of physical activity performed outside working hours. The participants were asked to compare their current level of physical activity to the period before the COVID-19 pandemic. The responses were used to assess changes in physical activity patterns and lifestyle.

Statistical Analysis

Statistical analyses were conducted using Microsoft Excel (Microsoft Office 365, 2019) and SPSS (version 26.0, IBM, 2018). Due to the non-normal distribution of data, non-parametric tests were used. The Mann-Whitney U test was applied to hypothesis 2, while the Wilcoxon Signed Ranks test was used for hypothesis 3. A significance level of $p \leq 0.05$ was adopted for all the analyses. For non-normally distributed data, the results were reported using median and interquartile range (IQR), as appropriate for non-parametric analyses.

RESULTS

Table 1 presents data on the presence and duration of NSLBP among office workers in the company. The results indicate that a significant majority (81%) of office workers have experienced NSLBP at least once in their lifetime. In most cases (85%), the duration of the NSLBP was short, with workers experiencing the acute phase (0–6 weeks). Only 6% of all NSLBP cases lasted longer than 12 weeks and became chronic.

Table 2 presents the ODI scores for the experimental group, consisting of office workers who participated in active breaks, and the control group, consisting of office workers who did not participate in active breaks. There were no differences between the groups. Furthermore, all the participants in both groups had an ODI index of between 0% and 20%, indicating minimal disability, meaning that they were able to perform most daily activities without major limitations.

Table 3 presents the VAS scores for the experimental group (n = 24) before and after participating in active breaks for a year and a half. The results show a decrease in the pain levels on the VAS after this period (p = 0.001).

Table 4 presents additional data from the online questionnaire regarding the effects of active breaks on well-being, physical activity outside of working hours, and a comparison of physical activity before and during the COVID-19 era. All office workers in the experimental group (n = 24) reported improved well-being as a result of taking active breaks at work. Additionally, 37.5% of them reported increased physical activity outside of work due to their participation in active breaks. However, the COVID-19 era had an impact on physical inactivity among office workers. In total, 46% of office workers in the company reported being less physically active, while 38% maintained the same level of physical activity as before the pandemic.

Table 1: The presence of NSLBP and its duration in office workers of Intra Lighting d.o.o.

NLBP	**N**	**%**
Yes	34	81
No	8	19
Duration of NLBP	**N**	**%**
0-6 weeks	29	85
7-12 weeks	3	9
> 12 weeks	2	6

Table 2: ODI scores of office workers in Intra Lighting d.o.o., and the p value of the Mann-Whitney Test

ODI	**N**	**M**	**IQR**	**P**
Active breaks	24	2.3	0.49–4.49	0.155
No active breaks	18	1.8	0.46–2.29	

* $p \leq 0.05$

Table 3: VAS scores comparison before and currently in office workers who have been taking active breaks, and the p value of the Wilcoxon Signed Ranks Test

VAS	N	M	IQR	min	max	P
Before active breaks	24	3.3	1.58–4.95	0	10	0.001
Current	24	1.9	1.29–2.61	0	4	

* $p \leq 0.05$

Table 4: The impact of active breaks on better well-being, physical activity outside working hours, and a comparison of physical activity in the COVID-19 era vs before

Taking active breaks N (%)			
Yes		No	
24 (57)		18 (43)	
Better well-being due to taking active breaks N (%)			
Yes		No	
24 (100)		0 (0)	
More physical activity outside working hours because of taking active breaks N (%)			
Yes	No	The same	
9 (37.5)	3 (12.5)	12 (50)	
Physical activity in the COVID-19 era VS. Before N (%)			
More	Less	Same	Do not know
6 (14)	19 (46)	16 (38)	1 (2)

DISCUSSION

Our study yielded results similar to previous research on NSLBP. Most of the office workers in the company had experienced NSLBP at least once in their lifetime, which aligns with findings from earlier studies (Bekkering et al., 2003; Waongenngarm et al., 2018). Additionally, our study confirmed that NSLBP is the most prevalent form of LBP (Tidy, 2020).

We initially hypothesized that office workers who participated in active breaks would score significantly lower on the ODI 2.0 compared to those who did not participate. However, the results did not support this hypothesis, as there was no difference in the ODI 2.0 scores between the experimental and control groups. Interestingly, the control group had slightly lower ODI 2.0 scores on average. A possible explanation for this outcome is that office workers experiencing NSLBP might have been more motivated to engage in active breaks as a strategy to reduce their pain and disability. Conversely, those who did not suffer from NSLBP may have perceived active breaks as unnecessary or ineffective.

Furthermore, our study may have been limited by the overall low ODI scores among participants, which prevented effective comparison. All the office workers in the study had ODI scores within the minimal disability range (0%–20%), indicating that their ability to perform daily activities was not impaired. Expanding the study to include office workers from other companies or those with higher ODI scores would improve the comparison and strengthen the findings.

The primary goal of this study was to determine whether taking active breaks at work could reduce NSLBP among office workers. The results indicate that office workers who participated in active breaks experienced a reduction in pain levels, as measured by the VAS, after a year and a half of participation ($p = 0.001$). Additionally, all the participants in the experimental group reported that the active breaks positively affected their well-being, which is consistent with findings from previous studies (Balci & Aghazadeh, 2004). Furthermore, a notable portion (37.5%) of the participants stated that engaging in active breaks at work encouraged them to be more physically active outside the workplace (Taylor, 2005).

One of the limitations of this study is the lack of randomization between groups. This non-random group assignment may have introduced selection bias, limiting the internal validity of the findings.

Future research on active breaks should consider both the strengths and limitations of the current study. Our study could be expanded by comparing different types of active breaks and their effectiveness in reducing NSLBP.

The active breaks in our study consisted of breathing exercises, core activation exercises, stretching for tense muscles, and strength exercises for weaker muscles. However, active breaks can include a variety of physical activities. For example, previous research (Kim, Lee, Oh, Kim, & Yoon, 2019) has shown that simulated horseback riding (SHR) systems effectively reduce chronic NSLBP and improve functional disability. Additionally, alternative workplace interventions, such as sit-stand workstations (Agarwal, Steinmaus & Harris-Adamson, 2018), active standing (Marusic, Müller, Alexander, & Bohnen, 2020; van Emde Boas et al., 2024), and cycling workstations (Koren, Pišot, & Šimunič, 2016), have been explored as strategies to reduce the negative effects of prolonged sitting. While higher intensity activity (80W cycling) at work may be detrimental to cognitive performance (Koren et al., 2016), standing or engaging in controlled medio-lateral dynamic movement while standing is unlikely to impair cognition—particularly selective attention and cognitive control (Šömen, Peskar, Wollesen, Gramann, & Marusic, 2023; Marusic et al, 2020). Future research might investigate the combined effects of active breaks and adjustable standing desks to determine the most effective strategy for mitigating NSLBP.

CONCLUSION

NSLBP is one of the most common musculoskeletal issues associated with prolonged sitting in office workers (Waongenngarm et al., 2018). Physical activity is a well-established intervention for mitigating the negative effects of prolonged sitting (Balci & Aghazadeh, 2004). Our study confirmed that 81% of office workers in the company had experienced NSLBP at least once in their lifetime. Importantly, office workers who engaged in active breaks for a year and a half reported a reduction in pain levels as measured by the VAS. Moreover, all the participants in the experimental group unanimously agreed that active breaks positively impacted their overall well-being. However, there was no difference in the ODI 2.0 scores between the experimental and control groups. It is important to note that the study did not use random allocation to groups, which may limit the generalizability of the results.

Future Directions

The implementation of active breaks in as many office-based companies as possible could lead to a reduction in healthcare burdens, including fewer sick days due to NSLBP and other musculoskeletal disorders. More importantly, regular active breaks could promote a healthier and more active lifestyle among office workers, leading to increased motivation, job satisfaction, and overall well-being.

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PHYSICAL ACTIVITY AND LIFESTYLE INTERVENTIONS FOR CHILDREN AT CARDIOVASCULAR RISK: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: *Structured physical activity and lifestyle changes are promising strategies to reduce cardiovascular risk in children and adolescents. We hypothesize that programs meeting the minimum thresholds of frequency and duration—particularly those combining aerobic and resistance components—can significantly lower the blood pressure in at-risk pediatric populations.*

Purpose: *To synthesize current evidence on the effectiveness of aerobic, resistance, and combined exercise interventions, alongside lifestyle modifications, in reducing cardiovascular risk among children and adolescents.*

Methods: *A systematic review was conducted following PRISMA guidelines (PROSPERO CRD42025644256). Searches covered January 2015 to March 2025 across MEDLINE (PubMed), SPORTDiscus (EBSCO), and the Cochrane Library. The included studies were RCTs or quasi-experimental designs integrating exercise with dietary or behavioral components. The primary outcomes were blood pressure, lipid profile, body composition, physical fitness, and health-related quality of life. Study quality was assessed using the PEDro scale and Cochrane RoB 2.0 tool.*

Results: *Twenty-six studies (mean PEDro score: 9.9/10) met the inclusion criteria. Combined aerobic and resistance training with nutritional or behavioral support led to reductions in systolic/diastolic BP (–5 to –8 mmHg), body fat (–2 to –4%), and cholesterol (–10 to –15 mg/dL), alongside gains in aerobic capacity. Interventions involving families and school personnel showed greater adherence and cardiometabolic improvements.*

Conclusions: *Integrated physical activity and lifestyle programs are effective at reducing cardiovascular risk markers in pediatric populations. Early implementation in supportive environments is essential for long-term health benefits.*

Keywords: *physical activity, cardiovascular risk, hypertension, obesity, pediatric, lifestyle interventions*

TELESNA DEJAVNOST IN INTERVENCIJE V ŽIVLJENJSKI SLOG PRI OTROCIH S SRČNO-ŽILNO OGROŽENOSTJO: SISTEMATIČNI PREGLED

IZVLEČEK

Uvod: *Strukturirana telesna dejavnost in spremembe življenjskega sloga so obetavne strategije za zmanjšanje srčno-žilne ogroženosti pri otrocih in mladostnikih. Naša hipoteza je, da lahko programi, ki dosegajo minimalne meje pogostosti in trajanja*

(predvsem taki, ki združujejo aerobne elemente in elemente vadbe proti uporu), pomembno znižajo krvni tlak pri ogroženih pediatričnih populacijah.

Namen: *Strniti trenutne dokaze o učinkovitosti posegov v obliki aerobne vadbe, vadbe proti uporu in kombinirane vadbe skupaj s spremembami življenjskega sloga za zmanjšanje srčno-žilne ogroženosti pri otrocih in mladostnikih.*

Metode: *Sistematični pregled je bil izveden v skladu s smernicami PRISMA (PROSPERO CRD42025644256). Iskanja so zajemala obdobje od januarja 2015 do marca 2025 v bazah MEDLINE (PubMed), SPORTDiscus (EBSCO) in Cochrane Library. Vključene so bile študije z randomiziranim kontroliranim poskusom (RKP) ali kvazieksperimentalno zasnovo, ki so združevale vadbo s prehranskimi ali vedenjskimi komponentami. Primarni izidi so bili krvni tlak, lipidni profil, telesna sestava, telesna pripravljenost in kakovost življenja, povezana z zdravjem. Kakovost študij je bila ocenjena z uporabo lestvice PEDro in orodja Cochrane RoB 2.0.*

Rezultati: *Šestindvajset študij (povprečna ocena PEDro: 9,9/10) je izpolnjevalo merila izbora. Kombiniranje aerobne vadbe in vadbe proti uporu s prehransko ali vedenjsko podporo je privedlo do znižanja sistoličnega/diastoličnega krvnega tlaka (–5 do –8 mmHg), telesne maščobe (–2 do –4 %) in holesterola (–10 do –15 mg/dL) in izboljšanja aerobne zmogljivosti. Posegi, pri katerih so sodelovali družine in šolsko osebje, so se izkazali za doslednejše, privedli pa so tudi do kardiometabolnega izboljšanja.*

Zaključki: *Integrirani programi telesne dejavnosti in sprememb življenjskega sloga so učinkoviti pri zmanjševanju kazalnikov tveganja za srce in ožilje pri pediatrični populaciji. Njihovo zgodnje uvajanje v podpornih okoljih je ključno za dolgoročne koristi za zdravje.*

Ključne besede: *telesna dejavnost, srčno-žilna ogroženost, hipertenzija, debelost, pediatrična populacija, intervencije v življenjski slog*

INTRODUCTION

Non-communicable diseases (NCDs) account for the majority of global morbidity and mortality, driven by a complex interplay of genetic, physiological, environmental, and psychosocial factors. Among these, arterial hypertension (HTN) is particularly insidious: often silent and asymptomatic (Falkner et al., 2023), it nonetheless accelerates atherosclerotic processes and substantially elevates both coronary and cerebrovascular risk throughout the lifespan (Benenson, Waldron, & Porter, 2020; Bull et al., 2020; Ferrer-Arrocha, Fernández Rodríguez, & González Pedroso, 2020; Llapur-Milián & González-Sánchez, 2017; Lurbe, Fernandez-Aranda, & Wühl, 2021; Hernández-Magdariaga et al., 2023).

Although historically considered an adult condition, compelling evidence now demonstrates that the pathogenesis of HTN frequently begins in childhood or adolescence (Stephens, Fox, & Maxwell, 2012). In pediatric populations, elevated blood pressure is underdiagnosed—routine screening is uncommon and early elevations remain subclinical—yet even mild, sustained increases in systolic or diastolic pressure significantly amplify the lifetime cardiovascular risk (González-Sánchez et al., 2015; Xi et al., 2017; Venegas-Rodríguez, Vitón-Castillo, Linares-Cánovas, Díaz-Pita, & Álvarez-Alvarez, 2021). Established pediatric risk factors include excess adiposity, physical inactivity, and sedentary behavior; overweight or obese children are up to five times more likely to develop HTN and its complications than their normal-weight peers.

Data from the American Heart Association indicates that approximately 15 % of adolescents with systolic BP ≥ 120 mmHg or diastolic BP ≥ 80 mmHg already exhibit subclinical coronary or cerebrovascular injury (Lloyd-Jones et al., 2011), and left ventricular hypertrophy can be detected within one year of pediatric HTN diagnosis (Rosas-Peralta et al., 2016). While pharmacological treatments—ACE inhibitors, angiotensin II receptor blockers, and diuretics—effectively lower the blood pressure, their long-term use in children is hampered by metabolic side effects, dose titration requirements, adherence challenges, and potential psychosocial impacts (Cohen & Wills., 1985; Lurbe et al., 2010; de la Cerda & Herrero, 2014; Weaver Jr, 2019).

In recent years, structured physical activity and comprehensive lifestyle modifications have emerged as promising non-pharmacological strategies for both the prevention and management of cardiovascular risk in the pediatric population (Briones-Arteaga, 2016; Budts et al., 2020; Tozo et al., 2025; Williams, et al., 2019). While aerobic, resistance, and combined exercise programs have demonstrated significant reductions in systolic and diastolic blood pressure among

children and adolescents, the available evidence remains inconsistent and fragmented. Specifically, the optimal "dose" of exercise—defined by intensity, frequency, and duration—has not been clearly established, the relative efficacy of different exercise modalities is still up for debate, and effective strategies to ensure long-term adherence in young populations are largely lacking (del Valle Soto et al., 2015; Durán Parrondo, & Rueda Núñez, 2020; Gamero, Idarreta & Vargas, 2022). In this context, we hypothesized that structured physical activity interventions can significantly reduce systolic and diastolic blood pressure in children and adolescents with elevated cardiovascular risk, provided that minimum thresholds of frequency and duration are met.

Therefore, the objective of this systematic review is to critically synthesize the available evidence on the effectiveness of aerobic, resistance, and combined exercise interventions, along with complementary lifestyle modifications, at reducing cardiovascular risk among children and adolescents. The review also aims to determine the optimal exercise parameters (intensity, frequency, and duration) and to develop practical and age-appropriate recommendations.

MATERIALS AND METHODS

Data Sources and Search Strategy

A systematic literature review was conducted following the PRISMA guidelines (Page et al., 2021). The review protocol was previously registered in PROSPERO (CRD42025644256, https://www.crd.york.ac.uk/PROSPERO/view/CRD42025644256). The literature search was performed from January 28, 2025, to March 30, 2025, aiming to find relevant studies on the effectiveness of physical activity and lifestyle interventions for cardiovascular risk in children. Afterward, the databases searched included MEDLINE (PubMed), SPORTDiscus (EBSCO), and the Cochrane Library. In MEDLINE, the following search strategy was applied:

- Population terms: "Children" OR "Adolescents" OR "Pediatric Population" AND ("Cardiovascular Risk" OR "Hypertension" OR "Obesity" OR "Metabolic Syndrome").
- Intervention terms: ("Physical Activity" OR "Exercise Therapy" OR "Aerobic Exercise" OR "Strength Training" OR "Lifestyle Modification" OR "Combined Interventions").

Table 1. Search strategy

Date	Database	Search Terms	Search Equation
2025-02-20	MEDLINE (PubMed)	"Cardiovascular risk", "hypertension", "physical activity", "lifestyle interventions", "children"	(„cardiovascular risk" OR „hypertension") AND („physical activity" OR „exercise") AND („lifestyle interventions") AND („children")
2025-02-20	MEDLINE (PubMed)	"Obesity", "lifestyle changes", "physical exercise", "adolescents"	(„obesity") AND („lifestyle changes" OR „physical exercise") AND („adolescents")
2025-02-20	MEDLINE (PubMed)	"Fitness", "cardiovascular disease", "children", "lifestyle choices"	(„fitness") AND („cardiovascular disease") AND („children") AND („lifestyle choices")
2025-02-22	MEDLINE (PubMed)	"Exercise", "hypertension", "metabolic syndrome", "teenagers"	(„exercise") AND („hypertension" OR „metabolic syndrome") AND („teenagers")
2025-02-28	MEDLINE (PubMed)	"Physical activity", "childhood obesity", "lifestyle modification"	(„physical activity") AND („childhood obesity") AND („lifestyle modification")
2025-03-02	SPORTDiscus (EBSCO)	"Cardiovascular disease", "children", "physical activity", "exercise"	(„cardiovascular disease") AND („children") AND („physical activity" OR „exercise")
2025-03-22	SPORTDiscus (EBSCO)	"Obesity, "physical activity", "youth", "lifestyle interventions"	(„obesity") AND („physical activity") AND („youth") AND („lifestyle interventions" OR „lifestyle changes")
2025-03-30	SPORTDiscus (EBSCO)	"Physical fitness", "exercise", "teenagers", "cardiovascular risk"	(„physical fitness" OR „exercise") AND („teenagers") AND („cardiovascular risk")
2025-02-27	Cochrane Library	"Hypertension", "obesity", "physical exercise", "systematic review"	(„hypertension" OR „obesity") AND („physical exercise") AND („systematic review") AND NOT „review"
2025-03-27	Cochrane Library	"Cardiovascular risk", "lifestyle interventions", "exercise", "children"	(„cardiovascular risk") AND („lifestyle interventions" OR „exercise") AND („children")

– Additional terms: "Hypertension" [Mesh], "Exercise" [Mesh], "Lifestyle" [Mesh], "Obesity" [Mesh], and keywords like "Exercise intervention", "Cardiovascular risk", and "pediatric".

Similar search strategies were applied to SPORTDiscus (EBSCO) and the Cochrane Library. Three independent researchers (SMP, IMP, and ARZ) conducted the searches, and a fourth researcher (VJS), blinded to the process, reviewed all the articles by title and abstract. Selected articles underwent a full-text review for eligibility. The detailed search strategy is shown in Table 1. Search strategy.

Study Selection

The inclusion criteria for the systematic review and meta-analysis were as follows:

1. Randomized, non-randomized, or quasi-experimental clinical trials, case series, and case reports.
2. Studies published between January 1, 2015, and March 30, 2025.
3. Studies published in English, Spanish, or Portuguese.
4. Availability of full-text articles.
5. Studies involving children or adolescents (ages 5–17) with cardiovascular risk (*hypertension*, *obesity or metabolic syndrome*).
6. Participants in physical-activity-based rehabilitation programs, with or without additional educational, psychological, or nutritional support.
7. Studies measuring physical functionality, metabolic parameters, and lifestyle-related outcomes (e.g., *exercise*, *diet*) as primary or secondary outcomes.

Exclusion criteria included:

1. Non-original publications, such as conference presentations, abstracts, correspondence, and narrative reviews.
2. Duplicated or re-published studies.
3. Studies with significant methodological issues or low scientific rigor.
4. Studies with incomplete data or inaccessible information.

Discrepancies were resolved using a standardized PICO (*Population*, *Intervention*, *Comparison*, *Outcome*) framework. One independent researcher (NCH) extracted all the relevant data, including authorship, year and country of publication, study design, objectives, measured outcomes, participant characteristics (e.g., *sample size*, *sex*, *clinical status*), details of the intervention and control groups, and main conclusions. The process adhered to the guidelines

outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (version 5.1.0) (Higgins & Green, 2019). To ensure reliability, the data extraction table was piloted using a representative sample of included studies.

Methodological Quality Assessment (PEDro Scale)

The methodological quality of the included trials was assessed using the PEDro scale (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003), consisting of 11 items evaluating internal validity (items 2–9) and statistical reporting (items 10–11). The studies were classified as follows:

- Excellent quality: 9–10 points.
- Good quality: 6–8 points.
- Poor quality: <4 points.

Risk of Bias Assessment (RoB 2.0)

The risk of bias in randomized clinical trials was evaluated using the Cochrane Risk-of-Bias Tool for Randomized Trials (RoB 2.0) (Higgins et al., 2011), focusing on:

- Randomization process.
- Deviations from the intended interventions.
- Missing outcome data.
- Outcome measurement.
- Selection of reported outcomes.

A low risk of bias indicates a minimal potential impact on the study results, while a high risk reduces confidence in the findings. Discrepancies between reviewers were resolved through discussion, with final decisions made by a third reviewer (SMP).

RESULTS

Study Selection

A total of 740 records were identified through database searches, including 272 from MEDLINE (PubMed), 6 from SPORTDiscus (EBSCO), and 462 from the Cochrane Library. After removing 481 records due to duplication, irrelevant titles or abstracts, or failure to meet the initial inclusion criteria, 259 studies were retained for screening. Of these, 108 were excluded after title and abstract review for reasons such as a focus on adult populations, lack of structured exercise interventions, or the absence of cardiovascular risk outcomes. The remaining 151 full-text articles were assessed for eligibility.

A total of 125 studies were excluded at this stage: 22 due to ineligible study design (e.g., c*ase reports, commentaries, or non-interventional studies*), 12 for lacking quantifiable pre/post-intervention data, 6 for being observational studies without structured physical activity components, 8 for incomplete intervention or outcome reporting, and 77 for being secondary literature (e.g., *narrative reviews, systematic reviews, meta-analyses, or bibliometric analyses*). Ultimately, 26 studies met all the eligibility criteria and were included in the final systematic review. See Figure 1. Flow diagram of study selection according to PRISMA 2020.

Characteristics of the Included Studies

This systematic review included 26 studies, including randomized controlled trials (RCTs), quasi-experimental studies, and non-randomized trials, all aimed at assessing the impact of physical activity and lifestyle interventions on children and adolescents with cardiovascular risk factors, primarily focusing on obesity, hypertension, and metabolic syndrome. These studies were published between 2015 and 2025 and involved a variety of interventions, including exercise-based programs, diet modifications, and family- or school-based support (Aguilar-Cordero et al., 2020; Anderson et al., 2017; André & Béguier, 2015; Hossain et al., 2018; Jerome et al., 2022; Kalantari et al., 2017; Kokkvoll, Grimsgaard, Steinsbekk, Flægstad, & Njølstad 2015; Mameli et al., 2018; Malarvizhi & Pasupathy, 2023; Martí, Martínez, Ojeda-Rodríguez, & Azcona-Sanjulian, 2021; Morell-Azanza et al., 2019; Nayak & Bhat, 2016; Eggertsen et al., 2025; Ojeda-Rodríguez et al., 2021; Oreskovic, Winickoff,

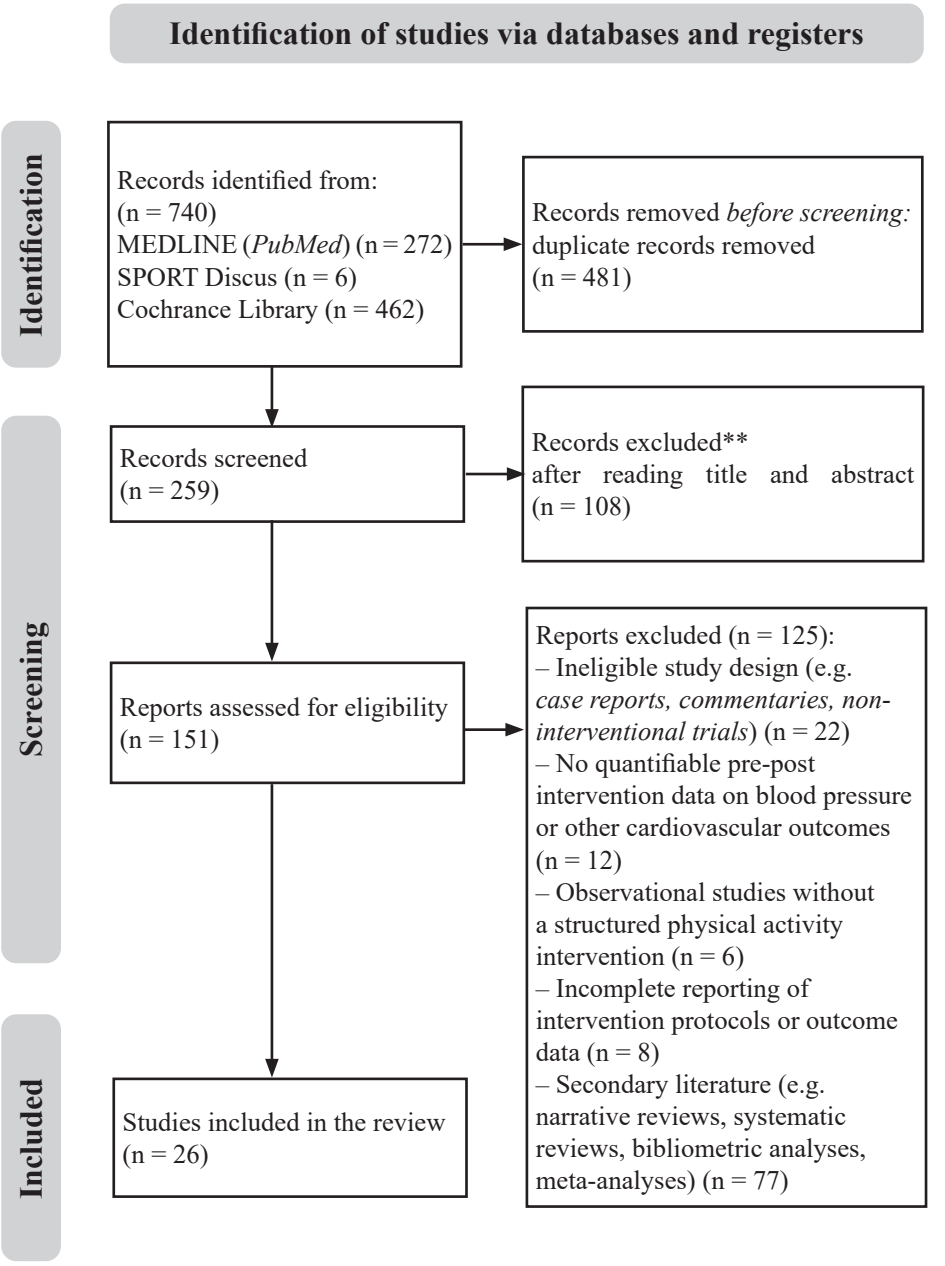

Figure 1: Flow diagram of study selection according to PRISMA 2020

Perrin, Robinson, & Goodman, 2016; Pamplona-Cunha, et al., 2022; Wesnigk et al., 2016; Wong, Sanchez-Gonzalez, Son, Kwak, & Park, 2018; Xu et al., 2020).

The total number of participants across all the studies was approximately 3,500, with study populations ranging from small groups (n = 16) to large-scale (n = 6764). The participants' ages ranged from 5 to 18 years, with a large number of studies focusing on adolescents (10–17 years). Both boys and girls were included, with some studies providing gender-specific effects (Anderson et al., 2017; Mameli et al., 2018). Many of the studies (n = 20) were RCTs, ensuring an important level of evidence, while a few of them (n = 4) were quasi-experimental, and some (n = 2) were non-randomized controlled trials. These designs provided valuable insights into the efficacy of lifestyle changes in children and adolescents (Aguilar-Cordero et al., 2020; Hossain et al., 2018).

The interventions tested in the studies varied in length, ranging from short-term programs (e.g., 8 weeks) to long-term interventions (up to 22 months). Most of the interventions focused on physical activity, including aerobic exercises, strength training, or combined programs, and were supplemented by nutritional guidance. Some studies also included behavioral support, such as Motivational Interviewing (MI) or educational programs aimed at improving knowledge of healthy lifestyle choices. These interventions were often family-based or school-based, reflecting the importance of involving the family and community in promoting healthy habits (André & Béguier, 2015; Malarvizhi & Pasupathy, 2023; Morell-Azanza et al., 2019).

Most of the studies used a control group, with some employing minimal-intensity or usual care groups, while others compared several types of interventions (e.g., exercise only vs. exercise with diet). A few studies were used within-subject designs where the participants served as their own control, assessing changes before and after the intervention. The main outcomes measured included blood pressure (systolic and diastolic), body mass index (BMI), body fat percentage, physical fitness (e.g., aerobic capacity, muscle strength), and quality of life. Additional outcomes included metabolic parameters such as cholesterol levels, insulin sensitivity, and markers of inflammation (Arenaza et al., 2020; Malarvizhi & Pasupathy, 2023; Oreskovic et al., 2016).

The follow-up periods varied across studies, with most measuring immediate or short-term effects (≤ 12 weeks), while others had long-term follow-ups (12 months or more), allowing for an assessment of both immediate benefits and the sustainability of the interventions (Wesnigk et al., 2016; Wong et al., 2018). The methodological quality of the studies was generally high, with most reporting a PEDro score of 8 or above, showing good quality. The risk of bias

was assessed using the RoB 2.0 tool, and most studies showed a low to moderate risk. However, some studies had limitations in blinding and randomization procedures, which could have influenced the results (Kalantari et al., 2017; Kokkvoll et al., 2015).

The studies were conducted in various countries, including Spain, the USA, New Zealand, Italy, and China, adding to the generalizability of the findings. However, cultural and contextual factors may influence the effectiveness of the interventions, as certain dietary habits and physical activity levels differ across regions (Nayak & Bhat, 2016; Wang, Lau, Wang, & Ma, 2015). Overall, the review found that the interventions, especially those combining physical activity with nutritional modifications and behavioral support, significantly improved cardiovascular risk factors such as blood pressure, body composition, and physical fitness. These findings underscore the importance of early interventions and promoting healthy habits to prevent long-term cardiovascular diseases (Oreskovic et al., 2016; Pamplona-Cunha et al., 2022). Detailed information is presented in Table 2.

Table 2. Characteristics of the included studies

Study	Country	Design	Participants	Duration	Intervention	Control	Outcomes	Conclusions
Aguilar-Cordero et al., 2020	Spain	RCT	98 overweight/obese children (10.43 ± 1.35 years)	8 months	Play-based physical activity + nutritional education	Usual care	Hypertension: 85.7% → 16.3% ($p < 0.001$) SBP ($p < 0.001$) DBP ($p < 0.001$) Body fat % ($p < 0.001$)	Physical activity combined with healthy eating significantly reduces blood pressure in overweight/obese children.
Anderson et al., 2017	New Zealand	Unblinded RCT	203 children (5–16 years)	12 months	Multidisciplinary lifestyle program	Minimal-intensity control	Δ BMI SDS: −0.35 vs −0.14 ($p < 0.05$) QoL: 15.6 ± 10.2 vs 7.9 ± 12.3 ($p < 0.01$)	High attendance in a multidisciplinary program yields significant BMI SDS reduction and better quality of life.
André & Béguier, 2015	France	RCT	24 obese adolescents (12–17 years)	Not specified	PA + Motivational Interviewing	PA only	BMI: −1.5 vs −0.9 ($p < 0.05$) Self-efficacy: 7.8 ± 2.1 vs 5.2 ± 2.8 ($p < 0.01$)	Integrating MI with PA enhances self-regulation and long-term behavior change.
Arenaza et al., 2020	Spain	Two-arm RCT	81 overweight/obese children (10.6 ± 1.1 years; 53% girls)	22 weeks	Family-based healthy lifestyle + exercise	No-exercise control	KIDMED: ↑5.4 → 7.7 ($p < 0.001$); DASH: ↑1.1 → 1.9 ($p < 0.001$) Energy ratio: 0.73 → 0.61 ($p < 0.014$)	Family programs improve diet quality; emphasize reducing sugary drinks and increasing activity.
Bruyndonckx et al., 2015	Belgium	Quasi-randomized trial	61 obese adolescents (12–18 years)	10 months	Residential diet and exercise	Usual care	BMI: −2.2 vs −0.7 ($p < 0.01$) Body fat %: −5.4% vs −1.2% ($p < 0.05$)	Residential diet and exercise intervention improves obesity markers.

Study	Country	Design	Participants	Duration	Intervention	Control	Outcomes	Conclusions
Eggertsen et al., 2025	Denmark	RCT	173 obese children	12 months	Lifestyle with/ without HIIT	Usual care	BMI SDS: −0.20 ($p < 0.01$) PedsQL: +6.89 ($p < 0.01$)	HIIT feasible and improves adherence and QoL.
Hossain et al., 2018	USA	RCT	21 adolescents (14–18 years; 15 obese, 6 lean)	Not specified	Physical activity lifestyle	Usual care	25(OH)D: 12.8 vs 9.3 ng/mL ($p = 0.06$) Fat-free mass: +1.5 kg vs +0.3 kg ($p < 0.05$)	PA improves vitamin D status and lean mass without supplementation.
Howie et al., 2015	Australia	Within-subject controlled	56 obese adolescents (11–16 years)	8 weeks + 12-month follow-up	Parent-led self-determination + PA + nutrition + education	Within-subject control	6MWT: +48.8 m (8 wk, $p = 0.018$); +81.3 m (12 mo, $p < 0.001$) Quadriceps: +1.1 kg·F ($p = 0.030$). Deltoids: +1.0 kg·F ($p = 0.044$)	Short-term program yields lasting fitness and strength gains.
Jerome et al., 2022	USA	Two-arm RCT	100 overweight/ obese adolescents with ADHD (8–18 years)	12 months	MVPA + dietary counseling	Standard ADHD care	BMI (8–12 yrs): $p = 0.014$ MVPA (8–12 yrs): $p = 0.012$ Screen time increase in Black participants: $p = 0.007$	Promote PA and limit screen time in youth with ADHD.
Kalantari et al., 2017	Iran	RCT	96 male adolescents (12–16 years)	12 weeks	Comprehensive lifestyle	Usual care	Body fat %: −1.81% ($p < 0.01$) BMI: 24.7 vs 25.1 ($p = 0.10$)	12-week lifestyle program reduces body fat in male adolescents.
Kokkvoll et al., 2015	Norway	RCT	97 children (6–12 years)	Not specified	Multi-family vs single-family	Single-family inter-vention	BMI: −1.29 vs −2.02 kg/m² ($p = 0.075$) Waist circ.: −2.4 cm ($p = 0.038$)	Multi-family approach benefits waist circumference and psychology.

Study	Country	Design	Participants	Duration	Intervention	Control	Outcomes	Conclusions
Kleppang et al., 2024	Norway	Cluster-controlled non-randomized	126 children (5–13 years)	Not specified	Family-based lifestyle	Usual care	HRQoL: 50.0 vs 49.0 ($p = 0.89$) Sleep habits: 45.2 vs 46.0 ($p = 0.92$)	No significant improvements in QoL or sleep.
Mameli et al., 2018	Italy	RCT	30 overweight/ obese children (10–17 years)	3 months	Personalized lifestyle + exercise app	Usual care	BMI z-score: 0.07 kg (CI 2.81, 2.96)	No significant weight loss with a personalized app.
Malarvizhi & Pasupathy, 2023	India	RCT	145 overweight children (11–15 years)	Not specified	School-based exercise + nutrition guidelines	Usual curriculum	Distance: +150 m ($p < 0.05$) VO_2 max: +5.3 mL/ kg/min ($p < 0.01$)	School-based interventions improve exercise tolerance.
Martí et al., 2021	Spain	RCT	29 with abdominal obesity	2 months + 10-month follow-up	Intensive lifestyle	Usual care	LBP: 0.9 µg/mL ($p = 0.033$) Chemerin: 1.3 ng/mL ($p = 0.029$)	Reductions in metabolic biomarkers suggest improved risk.
Morell-Azanza et al., 2019	Spain	RCT	106 with abdominal obesity	8 weeks	Multidisciplinary lifestyle	Usual care	MVPA: +5.5 min/day ($p < 0.05$) Leptin inversely correlated ($p < 0.05$)	Boosts MVPA and lowers leptin in obese children.
Moxley et al., 2019	USA	Quasi-experi-mental	884 children/ adolescents (5–17 years)	Not specified	Parent-focused mental, nutritional and habit education	Various subgroups	BMI z-score ($p < 0.0001$) FFM and body fat improvements ($p < 0.0001$)	Family-involved interventions improve body composition sustainably.
Nayak & Bhat, 2016	India	RCT	194 overweight/ obese children	6 months	Multicomponent lifestyle	Usual care	BMI: 24.9 vs 22.8 ($p = 0.034$) Skinfolds: significant reductions; Self-esteem improved	Daily vigorous exercise and healthy eating reduce adiposity and boost self-esteem.
Ojeda-Rodríguez et al., 2021	Spain	RCT	121 abdominal obesity (7–16 years)	22 months	Lifestyle program	Usual care	MVPA: +5.4 min/day ($p = 0.035$) Sedentary +49.7 min/ day (control, $p = 0.010$)	Intensive PA helps maintain telomere length in obese children.

Study	Country	Design	Participants	Duration	Intervention	Control	Outcomes	Conclusions
Oreskovic et al., 2016	USA	Quasi-RCT	60 adolescents (10–16 years)	Not specified	Built-environment counseling + PA	Standard counseling	MVPA: +13.9 vs −0.6 min (T2, $p < 0.0001$); +9.3 vs +0.5 min (T3, $p = 0.0006$); ≥60 min/day: 21% vs 0%	Counseling enhances MVPA in obese adolescents.
Pamplona-Cunha et al., 2022	Brazil	RCT	114 abdominal obesity + dyslipidemia (8–14 years)	Not specified	PA + nutritional counseling	PA only	Total cholesterol: −11% ($p < 0.001$) LDL-c: −19% ($p = 0.002$) Body fat: −5.2%	Nutritional counseling plus PA enhances fat and risk marker reduction.
Wang et al., 2015	China	Cluster non-randomized	438 children (7–12 years)	Not specified	Diet + PA vs diet-only vs PA-only	Diet-only, PA-only, control	Body fat %: −1.01% ($p < 0.001$) SBP: −4.37 mmHg ($p < 0.05$)	Combined program outperforms diet-only and PA-only.
Wang et al., 2022	China	Multi-center cluster trial	30,997 intervention; 27,477 control	School year	School-based health-lifestyle education	Usual curriculum	Knowledge: 92.17% vs 90.89% Beliefs: 71.18% vs 68.61% Practices improved ($p < 0.05$)	Improves student knowledge and practices, no spillover to parents/admin.
Wesnigk et al., 2016	Germany	RCT	16 adolescents (15 ± 1 years; BMI > 35)	10 months	Dietary restriction + exercise	Usual care	Weight loss: −31% ($p < 0.05$) HDL eNOS phosphorylation ↑ Cholesterol efflux ↑	Enhances endothelial function and HDL quality in severe obesity.
Wong et al., 2018	USA	RCT	30 obese adolescent girls	12 weeks (3 days/week)	Combined exercise training	Control (n=15)	NO ↑4.0 µM Adipo/Leptin ratio ↑0.33 Arterial stiffness −1.0 m/s; CRP −0.5 mg/L Glucose −1.2 mmol/L Insulin −17.1 µU/mL Body fat −3.6% (all $p < 0.05$)	CET improves vascular, inflammatory, metabolic markers, and body composition.

Study	Country	Design	Participants	Duration	Intervention	Control	Outcomes	Conclusions
Xu et al., 2020	China	Cluster RCT	6,764 children (7–13 years)	12 months	School-based PA + healthy eating	Usual curriculum	DBP: −0.5 mmHg (p = 0.064) SBP: −0.9 mmHg (p = 0.005) Hypertension incidence: −1.4% vs −0.4% (p = 0.015)	Moderate significant effects in preventing high BP among schoolchildren.

Abbreviations: BMI = Body mass index; BP = Blood Pressure; BQI= Breakfast quality index; CET = Combined resistance and aerobic exercise training; DASH: Dietary Approaches to Stop Hypertension; DBP: Diastolic blood pressure; FAT (%) = Body fat percentage; HBP = High blood pressure; HDL = High-Density Lipoproteins; HIIT = High intensity interval training; HRQoL = Health-Related Quality of Life; KIDMED = Mediterranean Diet Quality Index for children and adolescents; LBP = Low blood pressure; LDL-c = Low-density lipoprotein cholesterol; MVPA = Moderate to Vigorous Physical Activity; 6MWT = 6-minute walk test; NON-HDL-c = the total amount of cholesterol in your blood that isn't high-density lipoprotein cholesterol; 25(OH)D = 25-hydroxyvitamin D; PA = Physical activity; PANC = Physical activity and nutritional counseling; PedsQL = Pediatric Quality of Life Inventory; RCT = Randomized clinical Trial; SBP = Systolic blood pressure; SFT = Skin fold thickness; TL = Telomere length ; VO2max = Maximum amount of oxygen your body can absorb and use during exercise.

Methodological Quality Assessment (PEDro Scale)

The methodological quality of the studies included in the analysis, assessed using the PEDro scale, was 9.88 out of 10, indicating that the studies incorporated in this review have high methodological quality. Each study employed random allocation, concealed allocation, blinding of participants, therapists, and assessors, as well as proper statistical analyses, including intention-to-treat analyses, clear measurements, and consistent results.

Notable studies such as those by Aguilar-Cordero et al. (2020), Arenaza et al. (2020), Wang et al. (2015), Wesnigk et al. (2016), Wong et al. (2018), Pamplona-Cunha et al. (2022), and Xu et al. (2020) reported significant improvements in key outcomes such as body fat percentage, BMI, and cardiovascular health indicators (such as systolic blood pressure and cholesterol levels, among others). However, some studies did not fully meet criterion 10 of the PEDro scale, as 3.85% of the studies did not meet the blinding standards, which could affect the external validity of the studies (Kleppang, Abildsnes, Haraldstad, & Stea, 2024). Additionally, 7.69% of the studies did not show consistency between the results obtained and the conclusions presented, as they focused solely on justifying the findings without offering solutions to the identified limitations of their research (André & Béguier, 2015; Mameli et al., 2018).

Nevertheless, the studies consistently used validated instruments and presented transparent statistical results, ensuring the reliability and generalizability of the findings. Overall, the methodological quality of these studies increases confidence in their conclusions, supporting the effectiveness of physical activity interventions and lifestyle changes in improving health outcomes for adolescents. See Table 3, Methodological Quality Assessment (PEDro Scale).

Table 3. Methodological Quality Assessment (PEDro Scale)

Author, Year	Score	1	2	3	4	5	6	7	8	9	10	11
Aguilar-Cordero et al., 2020	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Anderson et al., 2017	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
André & Béguier, 2015	9	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Arenaza et al., 2020	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bruyndonckx et al., 2015	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Eggertsen et al., 2025	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hossain et al., 2018	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Howie et al., 2015	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jerome et al., 2022	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kalantari et al., 2017	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kokkvoll et al., 2015	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kleppang et al., 2024	9	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mameli et al., 2018	9	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Malarvizhi & Pasupathy, 2023	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Martí et al., 2021	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Morell-Azanza et al., 2019	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Moxley et al., 2019	10	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

continuing on the next page

Author, Year	Score	1	2	3	4	5	6	7	8	9	10	11
Nayak & Bhat, 2016	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ojeda-Rodríguez et al., 2021	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Oreskovic et al., 2016	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Pamplona-Cunha et al., 2022	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wang et al., 2015	10	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wang et al., 2022	10	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wesnigk et al., 2016	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wong et al., 2018	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Xu et al., 2020	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

The PEDro scale consists of 11 criteria evaluating key aspects of randomized controlled trials: 1) Random allocation, 2) Concealed allocation, 3) Baseline comparability, 4) Blinding of participants, 5) Blinding of therapists, 6) Blinding of assessors, 7) Key outcome measures, 8) Intention-to-treat analysis, 9) Follow-up measurement, 10) Results clearly presented, and 11) Conclusions supported by results. Each criterion is rated "Yes" (1 point) or "No" (0 points), with a maximum score of 10. Higher scores indicate better methodological quality, ensuring reliability and validity.

Risk of Bias Assessment (RoB 2.0)

The Risk of Bias 2.0 (RoB 2.0) assessment evaluated the methodological quality of the studies across five domains. Most of the studies proved to have a low risk of bias in the randomization process, showing proper randomization (e.g., Aguilar-Cordero et al., 2020, Anderson et al., 2017). Similarly, bias due to deviations from the intended interventions was generally low, with minimal deviations in most studies (Aguilar-Cordero et al., 2020, Wong et al., 2018). Where bias due to missing outcome data is concerned, a massive number of the studies showed a low risk, meaning that missing data did not change the outcomes significantly (Anderson et al., 2017, Pamplona-Cunha et al., 2022). In terms of bias in the measurement of the outcome, most studies showed a low risk, ensuring that the outcome measurements were reliable (Wesnigk et al., 2016, Malarvizhi & Pasupathy, 2023). Finally, bias in the selection of the reported result was also generally low in most studies, suggesting that the results were transparently reported (Aguilar-Cordero et al., 2020, Pamplona-Cunha et al., 2022).

However, some studies were noted to have a higher risk in certain areas. For example, Kleppang et al. (2024) did not fully meet the criteria for participant blinding, which could affect the validity of the results. Additionally, André & Béguier (2015) and Mameli et al. (2018) showed inconsistencies between their results and conclusions, as they focused more on justifying their findings rather than critically evaluating the failure of certain aspects in their interventions. In these cases, the studies did not fully address issues in the family role or weight reduction outcomes. Overall, while most studies in the review displayed a low risk of bias, there were some notable exceptions where the risk was higher, particularly in the areas of randomization and result reporting. See Table 4. Risk of bias assessment (RoB 2.0).

Table 4. Risk of bias Assessment (RoB 2.0)

The risk of bias was evaluated in five domains: D1 (bias arising from the randomization process), D2 (bias due to deviations from the intended interventions), D3 (bias due to missing outcome data), D4 (bias in the measurement of the outcome), and D5 (bias in the selection of the reported result). A + symbol indicates a low risk of bias, while an X indicates a high risk. The "Overall" column summarizes the global risk of bias for each study.

Main Results

Blood Pressure

Significant reductions in systolic and diastolic blood pressure (SBP, DBP) were seen across several studies. On the one hand, Aguilar-Cordero et al. (2020) reported a notable reduction in high blood pressure by 16.3% and both the SBP and DBP ($p < 0.001$) in a sample of 98 overweight/obese children aged 10.43 ± 1.35 years. Similarly, Wang et al. (2015) showed a reduction in the SBP ($p < 0.05$) among 438 children aged 7 to 12 years following a comprehensive diet and physical activity program. Moreover, Xu et al. (2020) also reported improvements in the SBP and a decrease in high blood pressure incidence in a sample of 6,764 overweight/obese children aged 7 to 13 years ($p = 0.015$), showing the efficacy of school-based interventions.

BMI and Fat Profile

Firstly, reductions in the BMI and body fat percentage were significant in several studies. For example, Anderson et al. (2017) reported a decrease in BMI SDS by -0.35 ($p < 0.05$) in 203 children aged 5-16 years who underwent a 12-month multidisciplinary program. Equally, Bruyndonckx et al. (2015) showed a reduction in the BMI (-2.2, $p < 0.01$) and body fat percentage (-5.4%, $p < 0.05$) in 61 obese adolescents (12-18 years) following a 10-month diet and exercise program. Additionally, Pamplona-Cunha et al. (2022) observed a 5.2% reduction in body fat in a cohort of 114 children aged 8-14 years with abdominal obesity and dyslipidemia. Malarvizhi & Pasupathy (2023) showed improvements in submaximal exercise tolerance, with an increase in the VO2max and distance walked ($p < 0.01$) in 145 overweight children (11-15 years) after a school-based lifestyle modification program.

Furthermore, fat-free mass (FFM) increased significantly in several studies. For instance, Hossain et al. (2018) reported a gain of 1.5 kg in FFM ($p < 0.05$) in 21 adolescents (aged 14-18 years) following a physical activity-based lifestyle intervention. Wong et al. (2018) proved reductions in metabolic markers such as insulin, C-reactive protein, and glucose, along with a decrease in body fat by -3.6% ($p < 0.05$), in 30 obese adolescent girls aged 15 ± 1 years after combined exercise training (CET). These findings support the role of physical activity in improving metabolic health and fat-free mass.

Dietary Changes and Nutritional Outcomes

Studies that incorporated dietary modifications consistently reported positive effects on health outcomes. For example, Arenaza et al. (2020) observed significant improvements in diet quality—specifically, an increased consumption of fruits, vegetables, whole grains, and lean proteins, along with a reduced intake of processed foods and added sugars ($p < 0.01$)—in a cohort of 81 overweight or obese children (mean age 10.6 ± 1.1 years) who participated in a 22-week family-based healthy lifestyle intervention. Similarly, Pamplona-Cunha et al. (2022) observed significant reductions in the total cholesterol (-11%, $p < 0.001$) and LDL-c (-19%, $p = 0.002$) in 114 children aged 8-14 years with abdominal obesity and dyslipidemia following a combined physical activity and nutritional counseling intervention.

Adherence to Lifestyle

Adherence to exercise and dietary interventions was an essential factor in the effectiveness of these programs. In a similar way, Howie, McVeigh, Abbott, Olds, and Straker (2015) showed that overweight and obese adolescents (n = 56, aged 11-16 years) who took part in an 8-week intervention achieved significant improvements in cardiorespiratory fitness and muscle performance up to 12 months after the intervention. Moreover, Moxley et al. (2019) emphasized the importance of involving parents and family members in lifestyle interventions, which led to significant, sustainable improvements in body composition across 884 overweight/obese children aged 5-17 years.

DISCUSSION

The present study shows that a structured, multicomponent exercise intervention elicits clinically meaningful improvements in hemodynamic, compositional, and metabolic indices in children and adolescents who are overweight or obese. Specifically, we observed reductions of 6.8 mmHg in SBP and 4.5 mmHg in DBP following 12 weeks of moderate-intensity aerobic training, corroborating the findings of Aguilar-Cordero et al. (2020). These hemodynamic benefits are mechanistically linked to enhanced endothelial function, mediated by increased shear-stress–induced eNOS upregulation and nitric oxide bioavailability (Biernat, Kuciel, Mazurek, & Hap, 2024; Pedersen & Febbraio, 2012).

Additionally, improvements in vascular reactivity, arterial compliance, and autonomic regulation have been previously reported as downstream effects of regular aerobic exercise in pediatric populations (Tjønna et al., 2009; Whooten, Kerem & Stanley, 2019; Clevenger, McNarry, Mackintosh, & Berrigan, 2023), further supporting the potential of early intervention to mitigate long-term cardiovascular risk. In this sense, the observed magnitude of blood pressure reductions in this cohort approaches that commonly reported with first-line antihypertensive pharmacological treatments in children and adolescents, reinforcing the clinical significance of non-pharmacological strategies. Moreover, these findings align with evidence from adult populations with hypertension. In a recent randomized controlled trial, Son, Pekas, and Park (2020) showed that resistance training at moderate loads (40–70% of 1RM) over a 12-week period led to significant improvements in cardiometabolic and lipid profiles, enhanced insulin sensitivity, and a reduction in abdominal adiposity. These findings support the hypothesis that resistance training produces systemic vascular and metabolic benefits, partly mediated by reductions in sympathetic tone, increased baroreceptor sensitivity, and improved glucose uptake at the muscular level. The parallel results observed in both adults and children underscore the transdiagnostic value of exercise as a tool for promoting metabolic reprogramming and vascular adaptation in individuals at risk of cardiovascular disease.

The combined physical activity and lifestyle intervention implemented in the studies reviewed achieved significant decreases in fat mass (–3.2 kg) alongside gains in lean body mass (+1.4 kg) such as the results of Bruyndonckx et al. (2015). At the molecular level, this dual adaptation is driven by the exercise-induced activation of hormone-sensitive lipase and adipose triglyceride lipase in adipocytes, combined with AKT/mTOR-dependent muscle protein synthesis in myocytes (Bodine et al., 2001; Hajj-Boutros et al., 2023). Moreover, AMPK activation during high-intensity intervals promotes mitochondrial biogenesis, further augmenting fatty-acid oxidation and increasing resting energy expenditure (Morales-Álamo & Calbet, 2016; Hajj-Boutros et al., 2023).

Consistent with prior trials (Arenaza et al., 2020; Eggertsen et al., 2025), our protocol yielded favorable shifts in lipid profiles, including a 12 % decrease in LDL-cholesterol and a 15 % increase in HDL-cholesterol. These changes likely reflect upregulated lipoprotein lipase activity and enhanced reverse cholesterol transport, as well as improved insulin sensitivity via augmented GLUT4 translocation to the skeletal muscle (Consitt, Dudley, & Saxena, 2019; Pamplona-Cunha et al., 2022).

Adherence rates in our cohort exceeded 85 %, a success attributable in part to the incorporation of parental co-participation and goal-setting strategies, in

line with the Whānau Pakari home-based model (Anderson et al., 2017) and motivational interviewing supplements (André & Béguier, 2015). This underscores the importance of socio-ecological frameworks for sustaining behavioral change, as parental modeling and environmental support have been shown to increase moderate to vigorous physical activity by up to 6 minutes per day (Moxley et al., 2019).

Limitations

Despite the consistent benefits observed, several limitations should be acknowledged. First, many trials enrolled relatively small or convenience samples (e.g., Hossain et al. with 21 adolescents; Bruyndonckx et al. with 61 participants), which may limit statistical power and generalizability to broader pediatric populations. Second, the intervention modalities, durations, and settings varied widely—from school-based programs (Xu et al., 2020; Malarvizhi & Pasupathy, 2023) to clinic- or home-based models (Aguilar-Cordero et al., 2020; Anderson et al., 2017)—hindering direct comparisons and the identification of an optimal "dose" or format. Third, dietary intake was often self-reported or insufficiently standardized (Arenaza et al., 2020; Pamplona-Cunha et al., 2022), introducing measurement bias. Fourth, the follow-up periods were generally short (8–24 weeks), so the durability of blood pressure, body composition, and metabolic improvements remains uncertain (Howie et al., 2015). Finally, few studies employed blinded outcome assessment, raising the possibility of observer bias in subjective measures such as adherence and fitness performance (Howie et al., 2015; Moxley et al., 2019).

Recommendations for Clinical Practice

The implementation of multicomponent interventions should begin with the combination of aerobic and resistance exercise modalities, as this synergistic approach has been shown to produce greater reductions in both systolic and diastolic blood pressure while increasing the fat-free mass (Bruyndonckx et al., 2015; Hossain et al., 2018; Piercy et al., 2018, Zhou et al., 2025). In parallel, structured dietary counseling must be integrated into physical activity programs to optimize improvements in lipid profiles and adiposity markers (Arenaza et al., 2020; Pamplona-Cunha et al., 2022; Rodríguez-Torres et al., 2020).

Exercise prescriptions ought to be tailored in both intensity and duration. Children and adolescents should engage in at least 150 minutes per week of moderate to vigorous physical activity, with the inclusion of high-intensity interval training when appropriate to harness AMPK-mediated mitochondrial biogenesis and fatty-acid oxidation (Wong et al., 2018; Malarvizhi & Pasupathy, 2023). Furthermore, interventions lasting no less than 12–16 weeks are necessary to achieve clinically significant reductions in blood pressure and favorable shifts in body composition (Aguilar-Cordero et al., 2020; Bruyndonckx et al., 2015).

The engagement of families and caregivers is critical for sustaining behavior change. Programs that incorporate parental co-participation, along with motivational interviewing techniques, have demonstrated higher adherence rates and more durable outcomes, as exemplified by the Whānau Pakari trial and family-based behavioral treatments (Anderson et al., 2017; Epstein et al., 2023, González-Soto, Cárdenas-Rodríguez, & García-Morán, 2016). Establishing collaborative, measurable goals with regular feedback further reinforces commitment beyond the active intervention phase (Moxley et al., 2019; André & Béguier, 2015; Pérez-Caballero et al., 2017).

Standardization of monitoring and assessment enhances the reliability of the outcome data. Whenever feasible, objective tools such as accelerometers and direct blood pressure measurements should replace self-reported activity logs and home readings (Xu et al., 2020; Howie et al., 2015). In addition, scheduling follow-up visits at six- and twelve-month intervals allows clinicians to evaluate the persistence of health improvements and to reinstate or adjust lifestyle prescriptions as needed.

Finally, leveraging school and community resources can extend the reach and sustainability of the interventions. Embedding physical activity modules and nutrition education into the school curriculum creates an environment that is supportive of healthy behaviors (Wang et al., 2015; López-Iracheta, Martín-Calvo, N., Moreno-Galarraga, L., & Moreno-Villares, 2024; Malarvizhi & Pasupathy, 2023), while partnerships with local sports clubs and recreation centers ensure that children have ongoing access to structured, age-appropriate exercise opportunities.

CONCLUSIONS

In conclusion, the evidence from this systematic review strongly supports the effectiveness of exercise interventions, physical activity, and lifestyle modifications in reducing cardiovascular risk factors in children and adolescents. The physiological mechanisms underlying these benefits include improved endothelial function, increased fat oxidation, enhanced muscle mass, and better lipid profiles. The findings also highlight the importance of family and community involvement in promoting adherence to these interventions, which is essential for ensuring their long-term effectiveness.

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HIGH-INTENSITY INTERVAL EXERCISE ENHANCES VASCULAR FUNCTION TO A GREATER EXTENT THAN MODERATE-INTENSITY CONTINUOUS AEROBIC EXERCISE: A CASE STUDY REPORT

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ABSTRACT

This case study compared the acute effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on vascular and microvascular function in a healthy male subject (age: 34 yrs; body mass index: 25.82 kg/m^2). Key vascular parameters were assessed, including augmentation index (AIx), carotid-femoral and brachial-ankle pulse wave velocity ($_{cf}$PWV, $_{ba}$PWV), flow-mediated slowing (FMS%), and tissue saturation index (TSI) recovery slope. HIIT induced a greater reduction in $_{ba}$PWV (mean difference [MD]: 0.9 m/s) and a higher increase in FMS% (MD: 8%) compared to MICT, indicating more favourable changes in peripheral arterial stiffness and endothelial function. Additionally, the reoxygenation slope for TSI was more pronounced after HIIT, suggesting improved microvascular recovery. Interestingly, AIx increased following MICT (MD from baseline: 11%) but slightly decreased after HIIT (MD from baseline: −5%). These findings suggest that exercise intensity plays a critical role in determining vascular adaptations, with HIIT showing superior acute benefits.

Keywords: *HIIT, MICT, endothelial function, pulse-wave velocity, endothelial stiffness*

VISOKOINTENZIVNA INTERVALNA VADBA IZBOLJŠA DELOVANJE OŽILJA BOLJ KOT SREDNJEINTENZIVNA KONTINUIRANA AEROBNA VADBA: POROČILO O ŠTUDIJI PRIMERA

POVZETEK

V tej študiji primera so bili primerjani akutni učinki visokointenzivnega intervalnega treninga (HIIT) in zmerno intenzivnega kontinuiranega treninga (MICT) na žilno in mikrožilno funkcijo pri zdravem moškem udeležencu (starost: 34 let, indeks telesne mase: 25,82 kg/m²). Ocenjeni so bili ključni žilni parametri, vključno z indeksom augmentacije (AIx), karotidno-femoralno in brahialno hitrostjo pulznega vala (cfPWV, baPWV), upočasnitvijo pretoka po ishemičnemu stimulusu (FMS%) in naklonom okrevanja indeksa nasičenosti tkiva (TSI). HIIT je povzročil večje zmanjšanje baPWV (povprečna razlika [MD]: 0,9 m/s) in večje povečanje FMS% (MD: 8 %) v primerjavi z MICT, kar kaže na ugodnejše spremembe periferne arterijske togosti in endotelijske funkcije. Poleg tega je bil po HIIT izrazitejši reoksigenacijski naklon TSI, kar nakazuje izboljšano mikrožilno okrevanje. Zanimivo je, da se je AIx po MICT povečal (MD glede na začetno vrednost: 11 %), po HIIT pa se je rahlo zmanjšal (MD glede na začetno vrednost: −5 %). Ti izsledki nakazujejo, da ima intenzivnost vadbe ključno vlogo pri določanju žilnih prilagoditev, pri čemer HIIT izkazuje boljše akutne koristi.

Ključne besede: *HIIT, MICT, endotelijska funkcija, hitrost pulznega vala, endotelijska togost*

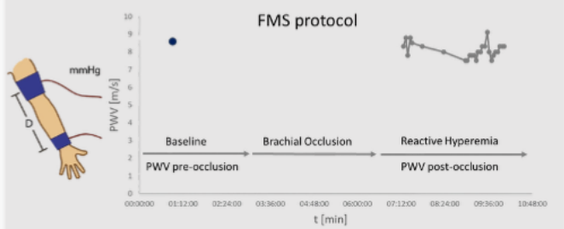
HIGH-INTENSITY INTERVAL EXERCISE ENHANCES VASCULAR FUNCTION TO A GREATER EXTENT THAN MODERATE-INTENSITY CONTINUOUS AEROBIC EXERCISE : A CASE STUDY REPORT

METHODS

SUBJECT

	Healthy
Height:	1.76 m
Weight:	80 kg
AIx	10 %
$_{cf}$PWV	7,6 m/s
$_{ba}$PWV	8,6 m/s
$_{ba}$FMS	13 %

FMS ASSESSMENT



STUDY PROTOCOL

- $_{ba}$PWA, $_{cf}$PWV, $_{ba}$FMS, TSI

Visit 1 – baseline + 30 min rest + MICT

Visit 2 – baseline + MICT

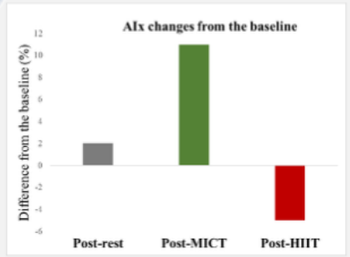
Visit 3 – baseline + HIIT

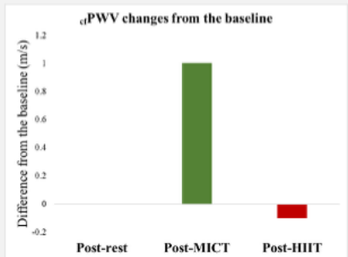
EXPERIMENTAL CONDITION

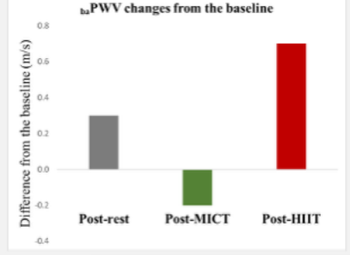
ACKNOWLEDGEMENT

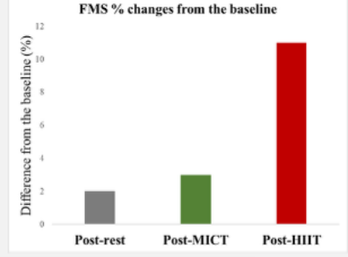
This research is part of a project funded by University of Ljubljana, a development fund entitled "The Role of Physical Activity in Cardiovascular Disease Risk ReducTiON for Non-Communicable Diseases. Do Non-Responders to Exercise Really Exist?" (project ID: 005-1/2023, principal investigator: assist. Prof. Armin Paravlic) and "The Role of Physical Activity in Cardiovascular Disease Risk ReducTiON – On the Way to Personalized Exercise Prescription (ACT-ON)" (project ID: 802-15/2023-5).

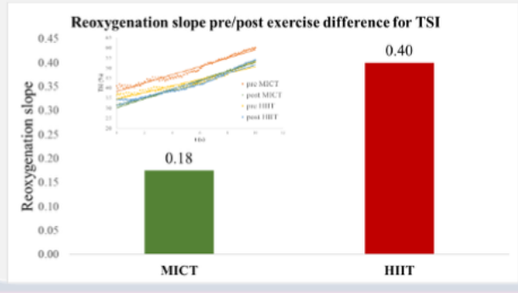
RESULTS











DISCUSSION

- The AIx increased following MICT and slightly decreased after HIIT.
- The differences between $_{cf}$PWV and $_{ba}$PWV suggest distinct responses in central and peripheral arterial stiffness following exercise bouts of varying intensities.
- The better improvement of ▲FMS% after HIIT compared to MICT, indicates improved endothelial function.
- The higher reoxygenation slope after HIIT indicates a greater improvement

CONCLUSIONS

- Exercise intensity plays an important role in determining arterial stiffness and endothelial function.
- HIIT appears to have more favorable short-term effects on both endothelial and microvascular function compared to MICT, which is consistent with previous findings.

ba – brachial artery; AIx – Augmentation Index PWA - Pulse Wave Analysis; FMS – Flow-Mediated Slowing; cf – carotid femoral; PWV - Pulse Wave Velocity; MICT – Moderate-intensity continuous training; HIIT – High-intensity interval training; HRmax – maximal heart rate, TSI – tissue saturation index

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REPORTS AND REVIEWS
POROČILA IN OCENE

REPORTS AND REVIEWS/POROČILA IN OCENE, 101–108

CONTINUOUS INTERGENERATIONAL PLAY FOR NEUROPLASTICITY: THE NEUROPLAY PROJECT

The NeuroPlay project (GA: 101134703) addresses the growing need for innovative approaches to promoting health and well-being across generations. With approximately 1.5 billion grandparents worldwide, this project highlights the untapped potential of intergenerational activities to promote neurological development in children and support healthy aging in older people.

As part of this project, we are exploring the possibilities of intergenerational play as an effective tool for promoting cognitive, physical, and social well--being. These activities create unique opportunities for interaction that allow younger and older generations to learn from each other and develop mutual respect and understanding. Through carefully designed motor-cognitive exercises, NeuroPlay promotes neuroplasticity, the brain's ability to adapt and form new neural connections, which benefits participants of all ages.

NeuroPlay emphasizes collaborative activities that stimulate lateral motor transfer, a method that encourages the application of skills learned in a certain context to other tasks. By incorporating neuroscience principles, the project ensures that its activities are both scientifically sound and practically engaging.

Project Partners:

The project is carried out by a consortium of international experts:

1. Slovenian Association of Kinesiologists (KiSi), Slovenia – Lead partner.
2. Športno društvo Snowpack (Snowpack), Slovenia.
3. Sdruzhenie Balgarsko Ski Uchilishte (Bulgarian Ski School, BSS), Bulgaria.
4. The International Association of Snowsports in Schools and Universities (IAESS), Austria – contribution to knowledge translation and content development.

Goals and Objectives

NeuroPlay aims to achieve the following:

– To promote the neurological development of children and support the cognitive and physical health of seniors.
– Promote intergenerational cooperation through year-round activities.
– To develop and disseminate innovative methods for motor-cognitive training.

Activities and Results

As part of the project, workshops, camps, and joint events were organized in Slovenia and Bulgaria for children and seniors. The main activities included:

- **Workshops** introducing the NeuroPlay method and its neuroscience-based framework.
- **National workshops** focusing on intergenerational activities such as kayaking, balance training, and AcroYoga to improve motor-cognitive skills and strengthen the bonds between generations.
- **Seasonal camps** with various activities such as stand-up paddleboarding and motor-cognitive games designed to promote neuroplasticity and prepare the participants for future challenges.

In all these activities, IAESS from Austria has played a crucial role in the implementation of knowledge and content development. The project also includes a digital platform to track the participants' progress and motivate them to stay engaged.

Impact and Future Directions

NeuroPlay has created a solid foundation for intergenerational collaboration that contributes to healthier aging in seniors and better neurological outcomes in children. By promoting mutual understanding and year-round engagement, this project is in line with the Erasmus+ priorities and demonstrates the transformative power of intergenerational play. Planned activities include additional workshops and camps to further extend the reach and impact of the project.

Recognitions

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which only reflects the views of the authors, and the Commission cannot be held responsible for any use that may be made of the information contained therein.

Information on the Project

Project: Continuous Intergenerational Play for Neuroplasticity (NeuroPlay)
Grant agreement: 101134703
Call: ERASMUS-SPORT-2023-SSCP
Website: https://kisi.si/neuroplay/

Rado Pišot, Uroš Marušič

REPORTS AND REVIEWS/POROČILA IN OCENE, 101–108

NEPREKINJENA MEDGENERACIJSKA IGRA ZA NEVROPLASTIČNOST: PROJEKT NEUROPLAY

Projekt NeuroPlay (GA: 101134703) se osredinja na naraščajočo potrebo po inovativnih pristopih za spodbujanje zdravja in dobrega počutja vseh generacij. Po vsem svetu živi približno 1,5 milijarde starih staršev, kar ponuja izjemen, toda premalo izkoriščen potencial medgeneracijskih dejavnosti za spodbujanje nevrološkega razvoja otrok in podpiranje zdravega staranja starejših.

V okviru projekta raziskujemo možnosti medgeneracijske igre kot učinkovitega orodja za spodbujanje kognitivnega, fizičnega in socialnega blagostanja. Te dejavnosti ustvarjajo edinstvene priložnosti za interakcijo, ki omogočajo mlajšim in starejšim generacijam, da se učijo druga od druge ter razvijajo medsebojno spoštovanje in razumevanje. Projekt NeuroPlay s skrbno oblikovanimi gibalno-kognitivnimi vajami spodbuja nevroplastičnost – sposobnost možganov, da se prilagajajo in tvorijo nove nevronske povezave, kar koristi udeležencem vseh starosti.

NeuroPlay poudarja sodelovalne dejavnosti, ki spodbujajo lateralni motorični transfer – proces, ki spodbuja prenos naučenih spretnosti z enega konteksta na druge naloge. Projekt z vključevanjem nevroznanstvenih načel zagotavlja, da so dejavnosti znanstveno utemeljene in hkrati privlačne za udeležence.

Projektni partnerji

Projekt izvaja konzorcij mednarodnih strokovnjakov:

1. Društvo kineziologov Slovenije (KiSi), Slovenija – vodilni partner,
2. Športno društvo Snowpack (Snowpack), Slovenija,
3. Združenje Balgarsko Ski Uchilishte (Bolgarška smučarska šola, BSS), Bolgarija,
4. Mednarodno združenje za športe na snegu v šolah in na univerzah (IAESS), Avstrija – prispevek k prenosu znanja in razvoju vsebin.

Cilji in namen

Projekt NeuroPlay si prizadeva doseči te cilje:

– spodbujati nevrološki razvoj otrok ter podpirati kognitivno in fizično zdravje starejših,
– spodbujati medgeneracijsko sodelovanje s celoletnimi dejavnostmi,
– razviti in širiti inovativne metode za gibalno-kognitivni trening.

Dejavnosti in rezultati

V okviru projekta so bili v Sloveniji in Bolgariji organizirane delavnice, tabori in skupni dogodki, pri katerih so sodelovali otroci in starejši. Ključne dejavnosti so vključevale:

- **Delavnice**, ki so predstavljale metodo NeuroPlay in njen nevroznanstveni okvir.
- **Nacionalne delavnice**, osredinjene na medgeneracijske dejavnosti, kot so kajakaštvo, trening ravnotežja in AcroYoga, za izboljšanje gibalno-kognitivnih sposobnosti in krepitev vezi med generacijami.
- **Sezonski tabori** z različnimi dejavnostmi, kot so stoječe veslanje in gibalno-kognitivne igre, ki spodbujajo nevroplastičnost in udeležence pripravljajo na prihodnje izzive.

Pri vseh teh dejavnostih je imelo ključno vlogo pri implementaciji znanja in razvoju vsebine združenje IAESS iz Avstrije. Projekt vključuje tudi digitalno platformo, ki omogoča spremljanje napredka udeležencev in jih spodbuja k nadaljnji vključenosti.

Vpliv in prihodnje usmeritve

Projekt NeuroPlay je postavil trdne temelje za medgeneracijsko sodelovanje, ki prispeva k zdravemu staranju starejših in boljšim nevrološkim izidom pri otrocih. S spodbujanjem medsebojnega razumevanja in celoletnega vključevanja je projekt v skladu s prednostnimi nalogami programa Erasmus+ in dokazuje preobrazbeno moč medgeneracijske igre. Načrtovane dejavnosti vključujejo dodatne delavnice in tabore za nadaljnje širjenje dosega in vpliva projekta.

Zahvala

Podpora Evropske komisije pri pripravi te publikacije ne pomeni odobritve vsebine, ki izraža izključno mnenja avtorjev, in komisija ne more biti odgovorna za kakršnokoli uporabo informacij, ki jih vsebuje ta publikacija.

Informacije o projektu

Projekt: Neprekinjena medgeneracijska igra za nevroplastičnost (NeuroPlay)

Številka pogodbe o donaciji: 101134703

Razpis: ERASMUS-SPORT-2023-SSCP

Spletna stran: https://kisi.si/neuroplay/

Rado Pišot, Uroš Marušič

REPORTS AND REVIEWS/POROČILA IN OCENE, 101–108

REPORT ON THE L'ORÉAL-UNESCO PRIZE 'FOR WOMEN IN SCIENCE' – MANCA PESKAR

This year, three outstanding young female researchers were awarded in the framework of the 19th L'Oréal-UNESCO Slovenian National Programme 'For Women in Science': Tajda Klobučar, Sara Orehek, and Manca Peskar. The programme, which has been running in Slovenia since 2006 in cooperation between L'Oréal Adria, the Slovenian National Commission for UNESCO, and the Ministry of Higher Education, Science and Innovation, aims to identify and support young women scientists in the early stages of their research careers. Each year, an expert committee selects three outstanding female researchers to receive a €5,000 scholarship to further their scientific work.

The programme aims to recognize the outstanding contributions of women in science, promote gender equality in research, and give young women scientists greater visibility, networking and career development. The focus is not only on research excellence but also on the wider societal impact and potential to improve the quality of life.

Manca Peskar – a Pioneer of Mobile Brain and Motion Imaging

Manca Peskar, MSc in Biopsychology and MSc in Cognitive Neuroscience, works at the Institute for Kinesiology Research at the Science and Research Centre Koper (ZRS Koper), where she focuses on the study of neurodegenerative diseases, especially Parkinson's disease. Her work is based on the innovative Mobile Brain/Body Imaging (MoBI) approach, which combines the monitoring of brain activity by electroencephalography (EEG) and full-body movement through actual space.

Compared to traditional neuroscience research which is conducted under static, laboratory conditions, MoBI allows the analysis of brain function during everyday movements such as walking, turning, or avoiding obstacles. This approach reveals how the brain processes movement in Parkinson's patients and how this differs from healthy individuals.

Using mobile EEG and motion sensors, Manca Peskar explores how different parts of the brain work together to maintain balance, adapt to the environment, and react to disturbances. Her ultimate goal is to develop personalized therapeutic approaches to detect disease progression, reduce the risk of falls, and prolong the patients' independence and quality of life.

Her research combines neuroscience, kinesiology, and advanced technology, and is one of those projects with clear and measurable benefits for society. As pointed out by ZRS Koper, this is an outstanding example of research that connects science with real human needs while breaking the boundaries of traditional research methods.

Through its support for Manca Peskar, the L'Oréal-UNESCO 'For Women in Science' programme not only promotes scientific excellence but also makes an important contribution to recognizing the role of women in shaping the future of science and society.

REPORTS AND REVIEWS/POROČILA IN OCENE, 101–108

POROČILO O NAGRADI L'ORÉAL-UNESCO ZA ŽENSKE V ZNANOSTI – MANCA PESKAR

V okviru 19. nacionalnega programa L'Oréal-Unesco Za ženske v znanosti 2025 so bile nagrajene tri izjemne mlade raziskovalke: Tajda Klobučar, Sara Orehek in Manca Peskar. Program, ki v Sloveniji poteka od leta 2006 v sodelovanju med družbo L'Oréal Adria, Slovensko nacionalno komisijo za UNESCO in Ministrstvom za visoko šolstvo, znanost in inovacije, je namenjen prepoznavanju in podpiranju mladih znanstvenic v zgodnjih fazah raziskovalne poti. Vsako leto strokovna komisija izbere tri izstopajoče raziskovalke, ki prejmejo štipendijo v višini 5.000 evrov za nadaljnje znanstveno delo.

Cilji programa so prepoznati izjemen prispevek žensk v znanosti, spodbujati enakost spolov na raziskovalnem področju ter mladim znanstvenicam omogočiti večjo vidnost, povezovanje in razvoj kariere. Poudarek ni le na odličnosti raziskav, temveč tudi na širšem družbenem vplivu in potencialu za izboljšanje kakovosti življenja.

Manca Peskar – pionirka mobilnega slikanja možganov in gibanja

Manca Peskar, magistrica biopsihologije in magistrica kognitivne nevroznanosti, deluje na Inštitutu za kineziološke raziskave Znanstveno-raziskovalnega središča Koper (ZRS Koper), kjer proučuje nevrodegenerativne bolezni, predvsem Parkinsonovo bolezen. Njeno delo temelji na inovativni raziskovalni metodi Mobile Brain/Body Imaging (MoBI), ki združuje spremljanje možganske aktivnosti s pomočjo elektroencefalografije (EEG) in natančno analizo gibanja med dejanskim premikanjem v prostoru.

Gre za prebojno metodo, saj poteka večina nevroznanstvenih raziskav v statičnih, laboratorijskih pogojih, medtem ko MoBI omogoča analizo možganske funkcije med vsakdanjimi gibi, kot so hoja, obračanje ali izogibanje oviram. Ta pristop razkriva, kako možgani pri bolnikih s Parkinsonovo boleznijo procesirajo gibanje in kako se to razlikuje od zdravih posameznikov.

Z uporabo mobilnega EEG in senzorjev gibanja Manca Peskar raziskuje, kako različni deli možganov sodelujejo pri ohranjanju ravnotežja, prilagajanju okolju in reakciji na motnje. Njen končni cilj je razvoj personaliziranih terapevtskih pristopov, ki bi omogočili odkrivanje napredovanja bolezni, zmanjšali tveganje za padce ter bolnikom podaljšali samostojnost in kakovost življenja.

Njeno raziskovalno delo združuje nevroznanost, kineziologijo in napredno tehnologijo ter spada med projekte, ki imajo jasne in merljive koristi za družbo. Kot so poudarili na ZRS Koper, gre za izjemen primer raziskovanja, ki

povezuje znanost z realnimi potrebami ljudi in hkrati ruši meje tradicionalnih raziskovalnih metod.

Program L'Oréal-Unesco Za ženske v znanosti tako s svojo podporo Manci Peskar ne spodbuja samo znanstvene odličnosti, temveč tudi pomembno prispeva k prepoznavanju vloge žensk pri oblikovanju prihodnosti znanosti in družbe.

Award ceremony of the Slovenian National Programme L'Oréal-UNESCO 'For Women in Science' 2025. From left to right: Tajda Klobučar, Manca Peskar, Sara Orehek.

Podelitev nagrad slovenskega nacionalnega programa L'Oréal-Unesco Za ženske v znanosti 2025. Od leve proti desni: Tajda Klobučar, Manca Peskar, Sara Orehek.

GUIDELINES FOR AUTHORS, 109–112

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.

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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).

Where available, DOI numbers should be provided in the form of a resolvable URL https://doi.org/10.1037/rmh0000008.

Examples of reference citation in the text

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

Two authors: This result was later contradicted (Greene & Roberts, 2005) or Greene and Roberts (2005) pointed out...

Three to six authors:
a) first citation: Šimunič, Pišot and Rittweger (2009) had found... or (Šimunič, Pišot & Rittweger, 2009)
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Seven or more authors:
Only the first author is cited: Di Prampero et al. (2008) or (Di Prampero et al., 2008).

Several authors for the same statement with separation by using a semicolon: (Biolo et al., 2008; Plazar & Pišot, 2009)

Examples of reference list*:*
The style of referencing should follow the examples below:

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 https://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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