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LITERACY OF RECREATIONAL ATHLETES ABOUT THE INFLUENCE OF THE ENVIRONMENT ON HEALTH AND PHYSICAL ACTIVITY

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Abstrakt

Environmental literacy should be an important part of every state's strategy. It has been shown that the environmental burden caused by various contaminants gradually influences not only the overall health of the population through the occurrence of various chronic diseases but also limits the possibility of various outdoor physical activities. The aim of the presented study is to analyse the knowledge of recreational athletes about the issue of environmental risks, including contaminants affecting the environment in the Slovak Republic, their effect on health and physical activities. The partial goal was to analyse the interest of recreational athletes in education in the given issue. The findings present an interesting overall view of recreational athletes on a currently still understudied issue. This study can provide an initial insight into the issue for further investigation in the future. With regards to living conditions, environment, health, and physical activity, it is necessary to ponder and first of all to understand the relationship "state - cause - consequence".

Keywords: *Environmental literacy, living conditions, health, environment, physical activity, symbiosis*

1. INTRODUCTION

Living conditions, including all environmental factors about public health, are understood in the current over-technological times as a complex of interactions and genetic characteristics of a person and the environment in which they live. Environmental pollution is a highly discussed topic in the world. It is a phenomenon that affects the entire world as well as people not only in terms of health but also the possibility of enjoying sports in the natural environment. The right to a favourable environment is also stated in Article 44 of the Constitution of the Slovak Republic. "Everyone has the right to a favourable environment, everyone is obliged to protect and improve the environment and cultural heritage, and no one may threaten or damage the environment and its resources beyond the extent established by law". A clean environment is therefore a key determinant of health and the existence of a healthy society. It should be remembered that environmental problems in the 21st century are already taking on a global character, including in Slovakia.

Physical activity and the environment

Physical activity in symbiosis with the natural environment (NE) is a very complex, still little-researched problem. However, there is no doubt that they mutually influence each other (Liba et al., 2012) define physical activity as a multifaceted movement activity of a person, or any form of movement characterized by human attributes such as purposefulness, social determination, cooperativeness, coordination, and others. However, it should be noted that performing physical activity outdoors depends primarily on a "healthy" natural environment" (Bama, 2015). There is also no doubt that in almost all sports it is important to become familiar with the natural environment, to be engaged, and to develop knowledge and appreciation of natural processes, including the

characteristics of the factors occuring in the natural environment - water, soil, air, weather, snow conditions, etc. (Cerezo-Esteve et al., 2022; Orr & Inoe, 2019; Orr et al., 2022).

Sports managers and participants in various sports events have taken a clean environment for granted for generations. Performing physical activity in the natural environment only emphasizes the key role - the necessity of preserving a healthy planet. Water quality, air quality, climate change, and other factors have a direct impact not only on the physical activity itself but first of all on the health of the individual and the population. Although many recreational as well as elite athletes perform physical activity in an outdoor environment, most of them perform it in a city, usually in a very densely populated area, often associated with a high level of pollution. There are studies related to increased air pollution and thus, negative consequences on the health of athletes during major sporting events (2006 Turin Olympics, 2010 Delhi Commonwealth Games, 2003-2004 English Football Cup Finals, etc.), (Bama, 2015; Orr & Inoe, 2019).

The Sports for Nature framework aims to implement transformative, nature-positive measures in sports by 2030, which will make it possible to promote physical activity in nature and at the same time contribute not only to the protection of nature and the environment itself but also to the protection of health. Back in 1995, Juan António Samaranch issued a statement: "The International Olympic Committee is determined to ensure that the environment becomes the third dimension in the organization of the Olympic Games" where the first dimension is sport, the second culture. This is also why the most significant progress in this field in the 21st century account for new, added relationships, namely the state of the environment in connection with physical activity and health. It points to the importance of being informed - where, how, and why an adult individual, athlete, or collectives perform physical activity in an outdoor environment. The fact that in recent years the connections of "green and clean" areas, places, and cities, but also the "green sports movement" have been brought to the fore can be considered positive. In the modern understanding of the 21st century, the "green path" can therefore be a sign of the path to improving life itself, the path to longevity, the path to healthy physical activity, and the field of scientific research (Bowler et al., 2010; Eštóková, 2010; Trojčák, 2022; NCZI, 2022).

The impact of a polluted environment on the health of recreational athletes

Health can be defined as a basic source and prerequisite for optimal functioning of the organism, it is the basis for the prosperous and fulfilling life of every individual (Cimboláková et al., 2019). The relationship between the NE and human health, the so-called "environmental health" is a term of the 21st century and must be understood as a complex between a person's genetic characteristics and the environment in which the individual lives. Exposure of the population, including sports-active individuals and sports teams to harmful substances present in all components of the environment is a significant trigger for the development of chronic diseases (Cimboláková et al., 2021; Halzlová, 2016) and non-communicable diseases (metabolic, cardiovascular, psychological, tumor and neurological), which unnecessarily reduce years spent in health, well-being and subsequent decline in the possibility of performing sports activities (Giroir et al., 2018; Kondáš, 2011; Meško, 2006). Review studies have been increasingly analysing different NE areas which influence humans. Research with concrete results in the field of physiological, physical health,

mental and cognitive processes, social field, and other influences has been confirmed. As a result of global development, people's health has become a neglected but increasingly significant problem in the 21st century. If timely and effective strategies are not implemented, the changing health patterns of the population can undermine the health of future generations as well (Mokdad et al. 2016; NCZI, 2022; NCZISK, 2019; Tran et al., 2022).

The Lancet Commission on Pollution and Health reports that a polluted environment is responsible for nearly 9 million premature deaths, equivalent to one in six deaths worldwide. This estimate was updated using data from the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 (Bama, 2015; Cimboláková et al., 2021; Cimboláková & Pavolová, 2020). As a result of the presence and action of risk factors in the NE, the number of deaths has increased by 7% since 2015, from 2020 it is more than 66 %, which can be considered an alarming figure (Fuller et al., 2022). Many of the pollutants that are known to affect human health are under regulatory control, but there are lengthy discussions about their long-term (chronic) effects on the body. In addition, persistent chemical substances can accumulate in human tissue and cause negative health effects during long-term exposure. An example can be perfluoroalkyl substances (PFAS). This is a group of almost 5,000 commonly used chemicals that can accumulate over time in the human population and the environment. They are an example of persistent organic pollutants also called "forever chemicals". They are an extremely difficult group of degradable chemicals which, in addition to occurring in the environment, are used in products due to their ability to increase the repellency of oils, and water or ability to withstand high temperatures. According to some estimates, about 6% of diseases, including chronic diseases, cancer, neurological and developmental disorders, and 8% of deaths in the world. Moreover, these numbers could be growing, taking into account only a small number of chemicals whose effects on health are verified (EEA, 2019; 2020). This is also why the most significant progress in this field in the 21st century is new, added relationships, namely the state of the environment in connection with physical activity and health. It points to the importance of being informed - where, how, and why an adult individual, athlete, or collectives perform physical activity in an outdoor environment as there is still little information and discussion about possible negative effects of, for example, polluted air and water at a given time. Healthy living conditions are among the basic factors in maintaining the quality of life, health, and the very future existence of a healthy society (Cimboláková, 2021A; NCZI, 2022).

2. AIM

This study aimed to analyse and expand knowledge about recreational athletes´ awareness of issues related to environmental risks, including contaminants affecting the environment in the Slovak Republic (SR), their impact on health, and physical activity. Furthermore, this study aimed to examine the athletes´ interest in education in the given issue. Respondents were informed in advance about the anonymity of the questionnaire and agreed to fill it out in advance.

3. METHODS

3.1 Sample, procedure

The sample consisted of 79 respondents (49 women and 30 men) and we excluded respondents who did not meet the criteria for inclusion since they did not identify as recreational athletes. 72 respondents (91

%) were included in this group. We could not utilise the data received from the other 7 respondents (9 %) in our research. Subjects came from the Slovak Republic, mostly from the Eastern Slovakia. All respondents were informed in advance about the anonymity of the questionnaire and agreed to fill it out in advance, including voluntary participation, informed consent, anonymity, confidentiality, potential for harm, and communication of results. The researchers always followed the ethical code of conduct when collecting data of respondents.

The sample mostly consisted of subjects who identified as employed (54 %), university students (32 %), secondary school students (10 %), and the unemployed group accounted for 4 %. Most respondents reported an age between 19 and 25 (45.5 %).

3.2 Diagnostics

The online questionnaire was used to examine the recreational athletes´ awareness of the state of the natural environment, its impact on health, and their interest in the environment where they perform physical activity. All subjects granted their approval for processing the data.

Selected multiple-choice questions were used for this publication:

1. Where do recreational athletes most often exercise?
2. Are the respondents interested in whether the area in which they exercise meets the
3. requirements for healthy "sports"?
4. Are the respondents sufficiently informed about the possible effects of a pollutedthe
5. environment on their health?
6. According to the respondents, which specific environmental risk factors have the most adverse effect on health and physical activity?
7. Would the respondents accept more information in the form of lectures, workshops on the topic of the possible negative effects of a polluted environment on the body?

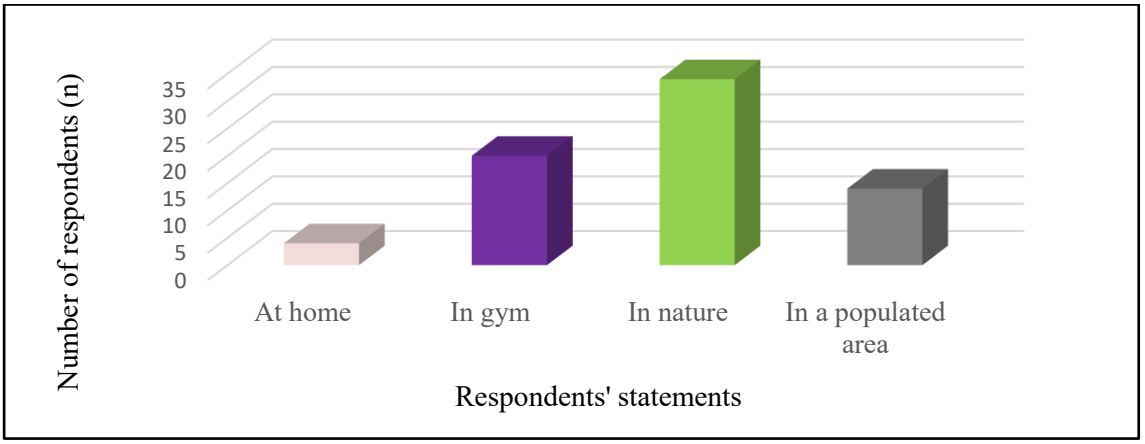
3.3 Statistics

Data were processed using basic mathematical statistical methods in Microsoft Office Excel and we used SmartArt graphics for the visualisation of our results.

4. RESULTS AND DISCUSSION

Regarding the first question in our survey where we examined both genders together (males, females) we found that 34 respondents (both genders) perform sports activities outdoors. 20 respondents do sports in the gym and 14 respondents do sports in a populated area – streets, roads, or in another built-up area. Only 4 respondents indicated that they like to do sports at home. The overall evaluation is shown in Fig. 1.

Fig.1 Place of sports activity (n=72; 42 males, 30 females)

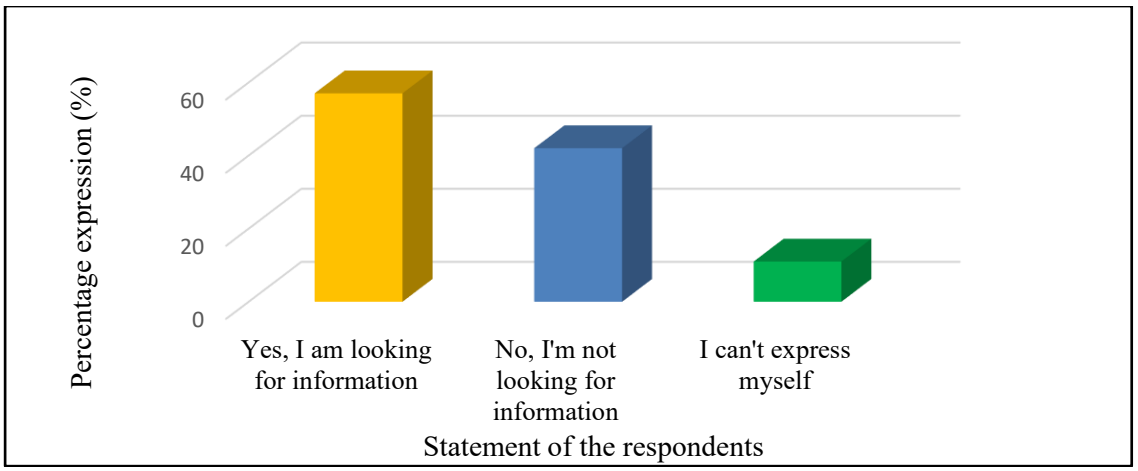


Source: own processing

The importance of physical activity in a non-contaminated environment is already being significantly recognized not only by scientists but also by the general public. That is why we were interested in whether the respondents are interested in the state of the environment in which they exercise.

More than half of the respondents (57 %) are interested in this issue and try to do sports in places that are as least polluted as possible. Less than half (42 %) of respondents do not search for this information. The overall evaluation is shown in Fig. 2.

Fig. 2 Literacy of the respondents - state of the environment (n=72; 42 males, 30 females)



Source: own processing

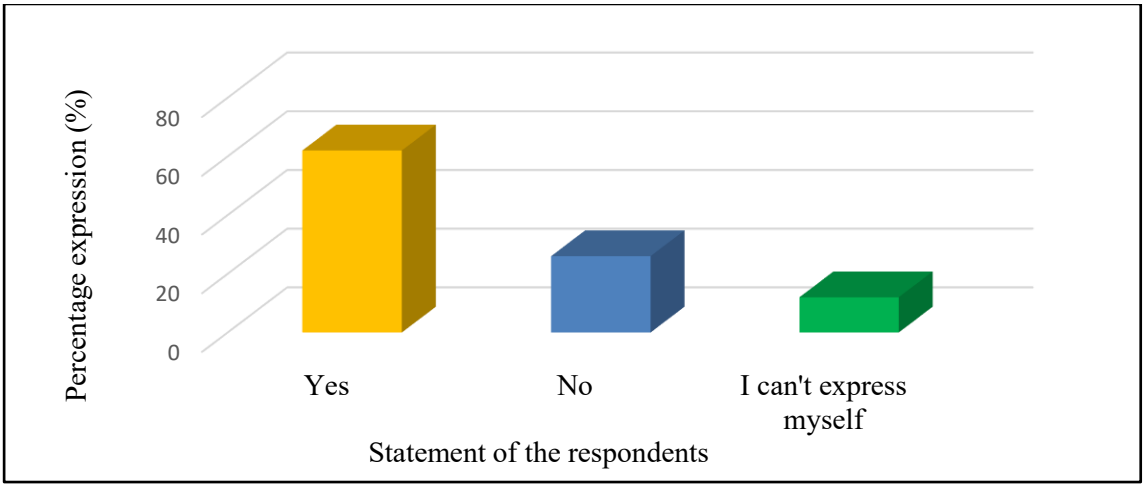
In a study by Thompson et al. (2011), Hartig (2003) it was found that physical activity in a clean environment was associated with reduced feelings of tension, confusion, anger, and depression while showing greater feelings of revitalization. Research on restorative environments reveals that the natural environment can promote psychological well-being by reducing psychophysical stress, inducing positive emotions, and facilitating the renewal of cognitive resources.

Many studies of psychological recovery in nature refer to evolutionary explanations that human beings evolved in natural environments and developed an innate tendency to respond positively to natural

environments. The results of our research partially correspond with the results of a 2019 study that examined high school students´ awareness of the state of the environment in Indonesia. Up to 64.13 % of respondents showed sufficient environmental awareness; almost 6 % of respondents were very well aware of the state of the environment. However, awareness of almost 30% of respondents was at a very low level (Amran et al., 2019).

In the question in which examined whether the respondents had information about the health risks that threaten them when performing sports activities in a polluted environment, 62 % of the respondents answered positively, but up to 12 % of the respondents could not express themselves at all, which we see as negative. The overall evaluation is shown in Fig. 3.

Fig.3 Literacy of respondents about health risks when exercising (n=72; 42 males, 30 females)

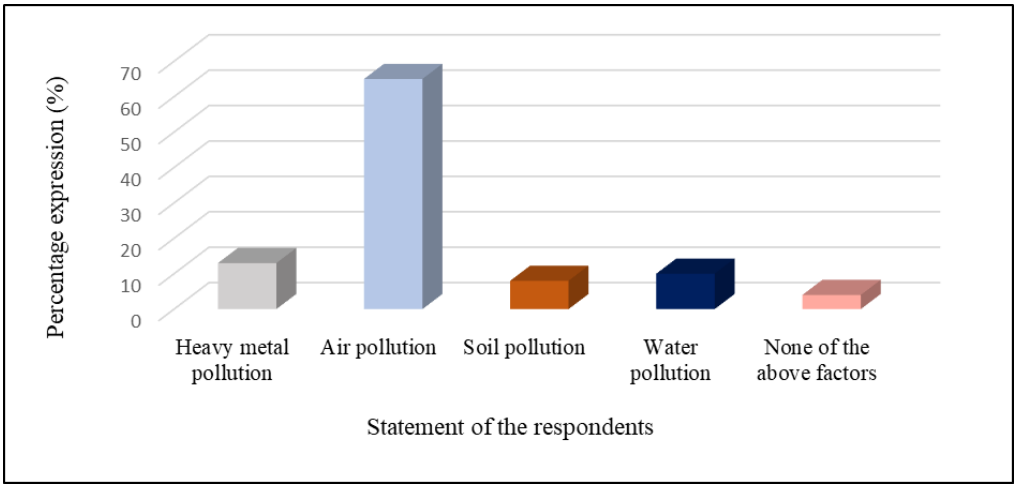


Source: own processing

Semrádová (2021) suggests that there is a very close connection between polluted environment and immunity, with a negative impact on the overall health of individuals up to 25 %. Studies conducted in areas with poor air quality in California proved that the incidence of respiratory diseases such as asthma is 3 times higher in the population that actively performs physical activity than in the population that does not perform any physical activity. This finding is more than alarming and calls for a solution. Concerns are also growing about the risk of illness when resting on the coast of the sea, due to its pollution and water contamination (Kalinkin, 2011).

We were also interested in which environmental risk factors the respondents consider to have the most adverse effect on their health. More than 65 % are mainly concerned about polluted air. We consider the answer of 4 % of respondents as a negative, who stated that none of the mentioned factors pose a risk for them and they have nothing to worry about. The overall evaluation is shown in Fig. 4.

Fig. 4 Environmental pollution factors considered by respondents to have the most adverse effect on their health (n=72; 42 males, 30 females)

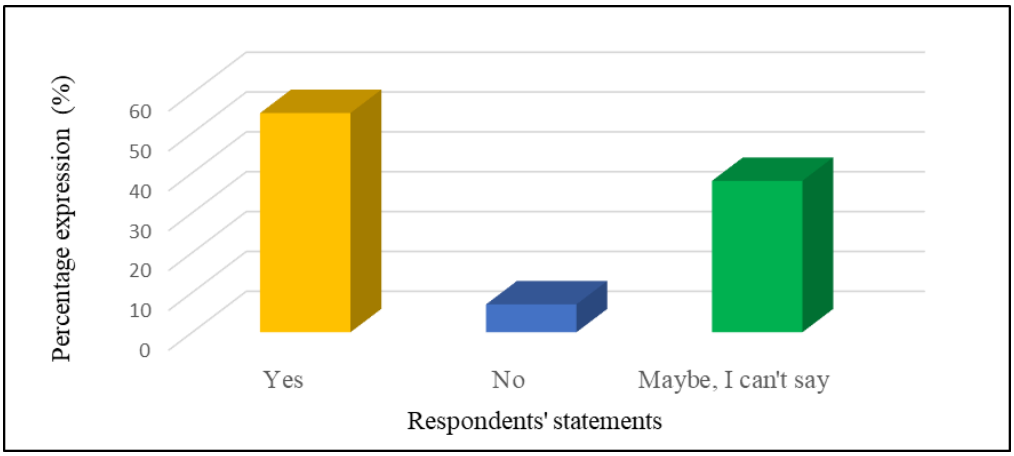


Source: own processing

A healthy environment and the space in which we live is one of the main determinants of human health. Based on estimates by the World Health Organization (WHO), almost every fourth death in the world is linked to the negative impact of a polluted environment on human health. Environmental burdens also include water and soil pollution, exposure to chemicals and heavy metals, and climate change. All these burdens significantly contribute to the development of cardiovascular diseases, and diseases of the digestive and respiratory systems. The influence of heavy metals on the body causes serious oncological diseases. However, the problem of the negative impact of a polluted environment on human health persists despite the measures taken (Kuriaková, 2018).

As part of the question of whether the respondents would accept more information about the polluted environment through lectures, workshops, or social networks, 55 % of the respondents expressed positively in the given question. Only 7 % of the respondents say that they are not at all interested in education in this area. The overall evaluation is shown in Fig. 5.

Fig. 5 Demand of the respondents for education in the analysed issue (n=72; 42 males, 30 females)



Source: own processing

The results partially correspond with the results of the author Schwartzstein (2020), who claims that until recently interest in education in this field was at a low level. The deteriorating climate has increased the interest in education in this issue, which was also confirmed by our survey. We can compare our survey with a survey that was conducted on a representative sample of 1,000 respondents and was focused on the interest of Slovak residents in improving the climate in the territory of the European Union. The results clearly show that the Slovaks definitely expect measures to be taken in the fight against climate change. As many as 73 % of the respondents expressed an interest in this issue and consider waste separation and reducing the use of automobile transport to be the most important. This can eventually lead to an improvement in air in the Slovak Republic.

The environmental burden caused by various pollutants (contaminants) in the individual components of the NE increasingly influences the overall health status of the entire population, and especially from a time point of view the occurrence of various chronic diseases. More and more often we come across declarations of emergencies in the Slovak Republic (in 2020 the Ministry of the Interior of the Slovak Republic – emergency of Chemko Strážske, 23.6.2023 emergency of increased ground-level ozone in the city of Bratislava, etc.). Therefore, to improve the environmental literacy of recreational athletes it is necessary to raise awareness, presentation, and visibility of the problem for example by improving media coverage as well as improving education in this field (Gupko, 2023).

5. CONCLUSIONS

Our research has provided an interesting insight into the issue. The main contribution of this study lies in the overall insight – recreational athletes' literacy in this field. Environmental problems and their impact on human health are also declared in the "Report on the Evaluation of the Strategic Document Operational Programme Slovakia 2021-2027". Also "Envirostrategy of Slovakia until 2030", states that the Slovak Republic faces many challenges, which points out the importance of solving environmental problems.

Data processed by the Slovak Hydrometeorological Institute (SHMÚ) as well as interim reports on the state of the NE also indicate that air pollution is the most significant contributor to the adverse effect of the NE on the health of the population, which was also confirmed in our research. Our findings suggest that despite the acceptable awareness of adults about the NE, they are not interested in the state of the NE in general, only in the case of performing outdoor activities. The overall awareness of the impact on their health is at a good level, even though, according to the results, the level of awareness of adults of the state of the NE is relatively low. The study can provide an initial insight for the future investigation of the given issue. With regards to living conditions, environment, and health, it is necessary to think about and understand the "state-cause-effect" relationship.

REFERENCES

Amran, A., Perkasa, M., Satriawan, M., Jasin, I., & Irwansyah, M. (2019). Assessing students 21st century attitude and environmental awareness: Promoting education for sustainable development through science education. *Journal of Physics: Conference Series*, *1157*(2), 022025. https://doi.org/10.1088/1742-6596/1157/2/022025

Bama, H. K. N. (2015). Major sporting

events and responsible tourism: Analysis of the 2013 Africa Cup of Nations (AFCON) tournament in Port Elizabeth, South Africa. *African Journal for Physical Health Education, Recreation and Dance*. 21, 205-219. https://www.academia.edu/28756357/Major_sporting_events_and_responsible_tourism_Analysis_of_the_2013_Africa_Cup_of_Nations_AFCON_tournament_in_Port_Elizabeth_South_Africa

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, *10*(1), Art. 1. https://doi.org/10.1186/1471-2458-10-456

Cerezo-Esteve, S., Inglés, E., Segui-Urbaneja, J., & Solanellas, F. (2022). The Environmental Impact of Major Sport Events (Giga, Mega and Major): A Systematic Review from 2000 to 2021. *Sustainability*, *14*(20), Article 20. https://doi.org/10.3390/su142013581

Cimboláková, I. (2021A): Posúdenie vplyvu ťažkých kovov na environmentálnu kvalitu v podmienkach SR. Habilitačná práca. TU Košice, 152s. https://www.crzp.sk

Cimboláková, I., Pastyrčák, H., Pavolová, H. (2021). Environmentálne faktory a ich vplyv na rozvoj chronických ochorení. 2021. In: *Atherosklerosa*. 1. Lékařská fakulta, s. 32-35, Praha. https://www.medvik.cz/bmc/link.do?id=bmc22006654

Cimboláková, I., Pavolová, H. (2020). *Enviroment a jeho vybrané aspekty*. Unibook E-shop UPJŠ Košice. 73s. https://unibook.upjs.sk/sk/biologia-a-ekologia/1326-enviroment-a-jeho-vybrane-aspekty

Cimboláková, I., Uher, I., Laktičová, K. V., Vargová, M., Kimáková, T., & Papajová, I. (2019). Heavy Metals and the Environment. *Environmental Factors Affecting Human Health*. IntechOpen. https://doi.org/10.5772/intechopen.86876

EEA (2019). Európska environmentálna agentúra. *Zem a pôda v Európe.* https://www.eea.europa.eu/www/sk/publications/signaly-eea-2019-zem-a

EEA (2020). Európska environmentálna agentúra. *Európa na ceste k nulovému znečisteniu.* https://www.eea.europa.eu/sk/signaly-eea

Eštóková, M. (2010). Postavenie environmentálneho zdravia v podmienkach Slovenskej Republiky a jeho inštitucionálna štruktúra. *In: Lekársky obzor*. ISSN 0457-4214. 59(9), s. 364-366. https://www.lekarsky.herba.sk/index.php/archiv/lekarsky-obzor-2010/37-lekarsky-obzor-92010/479-postavenie-environmentalneho-zdravia-v-podmienkach-sr-a-jeho-institucionalna-struktura

Fuller, R., Landrigan, P. J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., Caravanos, J., Chiles, T., Cohen, A., Corra, L., Cropper, M., Ferraro, G., Hanna, J., Hanrahan, D., Hu, H., Hunter, D., Janata, G., Kupka, R., Lanphear, B. & Yan, C. (2022). Pollution and health: A progress update. *The Lancet Planetary Health*, *6*(6), e535–e547. https://doi.org/10.1016/S2542-5196(22)00090-0

Giroir, B. P., & Wright, D. (2018). Physical Activity Guidelines for Health and Prosperity in the United States. *JAMA*, *320* (19), 1971–1972. https://doi.org/10.1001/jama.2018.16998

Gupko, I. (2023). Informovanosť dospelých o kontaminácii životného prostredia a dopade na ich zdravie. Záverečná bakalárska práca. UPJŠ, Košice. 54s. https://www.crzp.sk

Halzlová, K. (2016). *Životné prostredie a jeho vplyv na zdravie človeka—NPZ*. https://www.npz.sk/sites/npz/Stranky/NpzArticles/2013_06/Zivotne_prostredie_a_jeho_vplyv_na_zdravie_cloveka.aspx?did=2&sdid=59&tuid=19&page=full&

Hartig, T., Evans, G., Jamner, L., Davis, D., Arling, T., Avle, G., & Sweden. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, *23*, 109–123. https://doi.org/10.1016/S0272-4944(02)00109-3

Kalinkin, L. (2011). Защита населения от неблагоприятного влияния окружающей среды через развитие сферы физической культуры и спорта. https://cyberleninka.ru/article/n/zaschita-naseleniya-ot-neblagopriyatnogo-vliyaniya-okruzhayuschey-sredy-cherez-razvitie-sfery-fizicheskoy-kultury-i-sporta/viewer

Kondáš, M. (2011). Fyzická inaktivita. In Kondáš M.: *Sekundárna prevencia cievnych Mozgových príhod*. Agentúra Ministerstva školstva, vedy, výskumu a športu SR pre štrukturálne fondy EÚ. 75-79. ISBN: 978-80-8106-042-7.

Kuriaková, I., Sekelský, L., Púchovský, M. (2018). *Vplyv životného prostredia na zdravie obyvateľstva I.* MPaRV SR, 2019. Správa hodnotení strategického dokumentu. Slovenská agentúra životného prostredia. 204s. https://www.enviroportal.sk › eia › dokument

Liba, J., Buková, A. (2012). Pohyb a zdravie: Košice: UPJŠ. Ústav telesnej výchovy a športu. 54s. Unibook E-shop UPJŠ. https://unibook.upjs.sk/sk/telesna-vychova-a-sport/19-pohyb-a-zdravie-300258

Meško, D. (2006). Športovanie ako účinný preventívny prvok pred vznikom civilizačných ochorení. Via Practica. *3*, 12, 581-585. https://www.solen.sk/storage/file/article/ab5f48bc0c77c483e8e0fa8cdeb5b095.pdf

Mokdad, A. H., Forouzanfar, M. H., Daoud, F., Mokdad, A. A., El Bcheraoui, C., Moradi Lakeh, M., Kyu, H. H., Barber, R. M., Wagner, J., Cercy, K., Kravitz, H., Coggeshall, M., Chew, A., O'Rourke, K. F., Steiner, C., Tuffaha, M., Charara, R., Al-Ghamdi, E. A., Adi, Y. & Murray, C. J. L. (2016). Global burden of diseases, injuries, and risk factors for young people's health during 1990-2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet (London, England)*, *387* (10036), 2383–2401. https://doi.org/10.1016/S0140-6736(16)00648-6

NCZI (2022). Národné centrum zdravotníckych informácií (2022). Tlačové správy 2022. Kvalita životného prostredia priamo súvisí so zdravím [online] [cit. 20. november 2022]. www.nczisk.sk/Documents/aktuality/tlacove_spravy/2022/TS_Kvalita_zivotneho_prostredia_priamo_suvisi_so_zdravim_07042022.pdf

NCZISK (2019): Zdravotnícka ročenka Slovenskej republiky 2019. https://www.nczisk.sk/Documents/rocenky/2019/Zdravotnicka_rocenka_Slovenskej_republiky_2019.pdf

Orr, M., & Inoue, Y. (2019). Sport versus climate: Introducing the climate vulnerability of sport organizations framework. *Sport Management Review*, *22*(4), 452–463. https://doi.org/10.1016/j.smr.2018.09.007

Orr, M., Inoue, Y., Seymour, R., & Dingle, G. (2022). Impacts of climate change on organized sport: A scoping review. *WIREs Climate Change*, *13*(3), e760. https://doi.org/10.1002/wcc.760

Thompson C. J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science & Technology*, *45*(5), 1761.-1772. https://doi.org/10.1021/es102947t

Schwartzstein, P. (2020). *The Authoritarian War on Environmental Journalism*. (2020, júl 7). The Century Foundation. https://tcf.org/content/report/authoritarian-war-environmental-journalism/

Semrádová, B. (2021). *Vplyv životného prostredia na verejné zdravie v Košickom kraji v Slovenskej republike*. Journal of Global Science ISSN: 2453-756X (Online) Journal homepage: http://www.jogsc.com

Tran, K. B., Lang, J. J., Compton, K., Xu, R., Acheson, A. R., Henrikson, H. J., Kocarnik, J. M., Penberthy, L., Aali, A., Abbas, Q., Abbasi, B., Abbasi-Kangevari, M., Abbasi-Kangevari, Z., Abbastabar, H., Abdelmasseh, M., Abd-Elsalam, S., Abdelwahab, A. A., Abdoli, G., Abdulkadir, H. A. & Murray, C. J. L. (2022). The global burden of cancer attributable to risk factors, 2010–19: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, *400* (10352), 563–591. https://doi.org/10.1016/S0140-6736(22)01438-6

Trojčák, M. (2022). Informovanosť rekreačných športovcov o negatívnych vplyvoch znečisteného životného prostredia na ich zdravie. UPJŠ, Košice. Záverečná bakalárska práca. 52s. https://www.crzp.sk

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DEVELOPMENT OF SPECIFIC STRENGTH SKILLS OF UPPER LIMBS DUE TO TARGETED MOVEMENT INTERVENTION IN JUDOKAS IN CATEGORIES U12 – U16

Věra KNAPPOVÁ, Petr PEŠEK, Patrice MAREK

Abstract:
The presented work deals with the issue of grip strength and its development in the specific environment of combat sports. The research investigation compared the state of strength skills of U12-U16 judokas pre and post targeted movement intervention aimed at grip strength development. Probands were measured with a battery of 3 tests targeting upper limb strength skills and exposed to a targeted movement intervention over a 4-month period to stimulate the development of strength skills central to success in the sport. After the movement intervention, the boys' group showed statistically significant improvement in all tested parameters. Grip strength, paradoxically, improved mainly in the non-dominant upper limb.

Keywords: *judo, older school age, strength skills, training intervention, dynamometry.*

1. INTRODUCTION

There are not many sports in which grip strength has a dominant influence on the outcome of a combat. A specific group are grappling sports. The grip in judo is a specific kind of interaction between the hand and the kimono as an object. In order to hold the object, a considerable isometric grip force must be exerted by the flexors of the hand, and therefore power and precision grips are common in functional activities (Buriánek, 2018). Thus, it would be very appropriate to include specific training of this key skill in judo training. Kumi-kata, or grip patterns, form the basis for all other actions in judo, as each move can be performed using a specific grip. Almost half of the time of each fighting segment in a combat is devoted to fighting for the grip, with this fight itself taking between 14 and 18 seconds (Štefanovský, 2015). If a competitor can use a significantly better grip than his opponent, he/she is at an advantage to execute the throwing technique and thus can win the combat. However, as highly complex athletes, judoka do not only use maximum grip strength to gain an advantage over their opponent. Explosive grip strength to quickly deflect an opponent and upper extremity endurance strength to maintain the necessary grip throughout the combat are also important components.

Despite all the knowledge about strength skills, there is no comprehensive, uniformly accepted classification of them. Thus, classification and terminology depends on the individual aspects applied, such as the type of muscle contraction, the type of muscle activity, or the nature of the movement (Choutka and Dovalil, 1991). In foreign authors we can encounter a division of strength skills depending on the speed of the movement performed. There is an inverse relationship between force and velocity represented by a curve, where we can observe that maximum force is exerted at high loads and, on the contrary, maximum velocity is generated at low loads. Thus, the goal of strength and conditioning training is to improve strength skills across the entire load spectrum, and therefore their speed component (Maestroni et al., 2020). A comprehensive overview is also added in their publication by Hohmann, Lames and Letzelter (2010). They emphasize clarification of what adaptive action is to be achieved in training as a fundamental principle in the development of strength skills.

At the beginning of the older school age

period, we develop strength skills in judo mainly by means of resistances and games and using various exercises with own weight (push-ups, jumps, pull-ups). The use of so-called power inputs is also appropriate. This is the interruption of a training activity in order to insert a specific short strengthening exercise (e.g. 10 push-ups and 10 squats). After the execution, the guided training resumes. Strengthening should be focused on large muscle groups in lower positions, avoiding possible overloading of the spine with added loads. It is highly advisable to perform the exercises in a varied and fun way and not to skip the final stretching, compensatory and relaxation exercises. The uneven onset of puberty places considerable demands on the proper individual development of strength skills in each exerciser. Kučera, Kolář, and Dylevský (2011) emphasize the training of strength development in older school-aged athletes primarily in the training of weight training technique, general strength training, and the development of speed-strength skills.

2. RESEARCH OBJECTIVE

The aim of the research investigation was to test the strength skills focused on the specific area of grip strength in a group of judokas of categories U12-U16, before and after the application of a targeted movement intervention.

In order to evaluate the changes achieved in strength skills tests due to the targeted movement intervention, we set two research questions. In the first, we would like to examine the change in hand dynamometry tests of the dominant and non-dominant hand, therefore we hypothesize that the improvement will be statistically more significant in the dominant hand than in the non-dominant hand. Furthermore, we also expect that boys will show statistically significant improvement in the tests after the application of the movement intervention compared to girls.

3. METHODOLOGY OF THE WORK

The research group consisted of a training group of judokas from Judoclub Plzeň (hereafter JC Plzeň). This group consists of judokas of categories U12, U14 and U16. All the subjects or their legal representatives voluntarily agreed to the processing of personal information, data and photographs for the purposes of this investigation.

Thus, the final total number of probands consisted of 37 judoka (30 boys and 7 girls) aged between 10 and 15 years. The judokas in this category mostly attend training units 3 times a week for 1.5 hours and participate mainly in regional or republican tournaments.

The research data collection of the initial testing took place during the transition period after the end of the judo season. Output testing took place after the completion of the preparatory period and the application of our targeted movement intervention.

Table 1: Basic anthropometric data about the research population (source: own)

	Number	Age	Height (cm)	Weight (kg)
Research group	37	12,89 (1,33)	164,41 (11,45)	56,26 (14,37)
boys	30	12,83 (1,32)	165,87 (12,03)	57,75 (14,67)
girls	7	13,14 (1,36)	158,14 (4,85)	49,91 (10,92)

Standard deviation (SD) is given in brackets.

For the purpose of the research, a test battery was created consisting of three motor tests aimed at measuring upper limb strength.

1. test item – dynamometry

The hand dynamometry test determines the short-term maximum static-force capacity of the hand flexors. In general, hand grip strength is one of the important methods of measuring health and physical fitness (Čuta and Vážná, 2021). For judo, this test is a very useful indicator as it tests the maximum grip strength, which is widely used and needed by judoka for a good grip on the kimono. The Grip D hand dynamometer T.K.K. 5401 was used for data collection. The grip of the dynamometer was calibrated, i.e. with the possibility of adjusting the grip with respect to the dimensions of the probands' hand finger lengths. Testing was performed by repeatedly gripping the hand twice with the left and twice with the right, with the higher result counted. For each measurement, the participant was asked to squeeze the dynamometer with maximum effort for 3 seconds. After each measurement, probands rested for at least two minutes to allow sufficient recovery of energy resources as recommended by Buriánek (2018). The measured results were converted to the basic force units, newton (hereafter N).

Testing was performed in two predefined positions simulating a judo grip of both upper limbs. The first position was standing with the dynamometer in the forearm (90°), the grip of the dynamometer was a neutral grip (see Figure 1, left). This position simulates the opponent's collar grip in judo. The second test position was again standing, but this time the arm was flexed at the elbow (flexion 90° at the elbow) and the dynamometer was grasped in supination (external rotation) 90° (see Figure 1 right). This position simulates in judo a grip on the opponent's sleeve, most often held just in supination (underhand grip).

Fig. 1: Two dynamometry test positions

Source: own

2nd test item - endurance in the pull-up
This test is used to determine the endurance static-strength skill of the arms and brachial plexus. In judo, isometric endurance strength is often used in combats to keep an opponent at a safe distance, or in ground fighting. Probands perform maximal endurance in the overhand bend (see Figure 2). The basic position is taken using a chair. After starting, the individual must hold the chin over the trapeze bar for as long as possible. The test ends when the chin drops below the level of the bar (Havel and Hnízdil, 2009). During testing, probands were verbally motivated, as this test is demanding on both strength and willpower qualities, which can be a limiting factor.

Fig. 2: Test position for maximum endurance on the trapeze bar

Source: own

3rd test item - rope climbing
The final motor test was a 5 m rope climb in 1 minute. This test focuses on another distinct component of strength skills, namely the largest dynamic explosive force output of the UL. The rope climb is also one of the motor tests used by the Czech Judo Federation coaches to make regional and national selections. For judo, this test simulates the pulling power of an opponent during matches and is therefore widely used. The starting position was standing with both hands on the rope. At the start instruction, probands climbed in pairs for one minute (see Figure 3). Due to the testing of probands of different categories, all were allowed to climb with the help of their feet to ensure equal conditions. Ropes climbed were counted in halves, marked with tape on the rope.

Fig. 3: Rope climb test for 1 minute

Source: own

Movement intervention

The applied movement intervention was part of the training sessions in the preparatory period of the judoka. A special training program was incorporated into the regular training sessions twice a week, which included exercises and posture training to improve the tested indicators in judoka. These exercises did not require any specific aids. Judoka strengthened with their own body weight or in weight-matched pairs. Examples of each exercise are shown in Figures 4-10. The initial part of the training consisted of various movement games to warm up the body. In this busy part, stretches and push-ups were also frequently included to engage the upper limbs. This was followed by a progressive warm-up using relaxation, dynamic stretching and activation strengthening exercises. In these exercises, attention was also focused on the muscles of the upper limb, especially the hand flexors.

The preparatory part included various gymnastic elements and judo falls. In this part of the training we also included various types of low locomotion over the mat using mainly dynamic explosive arm strength.

The main part of the training included exercises to develop judo skills, initially focusing on the coordination and speed component. We mainly trained techniques more related to the use of grip and arm work, e.g. used to deflect the opponent. Another component consisted of practicing various combat situations, which included the use of strengthening inputs. These inputs always included exercises to strengthen the whole body. Within the upper limbs, rope climbing, push-ups, or pull-ups were most often included. The practice of techniques in pairs was complemented by strengthening exercises in the form of various carries, pull-ups and push-ups. It was age-appropriate to include some competitive component for more motivation and fun. In addition,

exercises related to gripping the opponent were part of the training sessions. We worked on the correct opponent's grip, variations of these grips, or on the contrary, getting rid of the opponent's grip by snatching. Judokas also practice grip strength very well during these exercises.

After practicing techniques and combat situations in training sessions, followed randori, in other words practice combats. During the combats, specific grips were used, for example by both sleeves or kimono collars, or individuals alternated between defensive and offensive positions. Thus, long combats already created physically demanding conditions and with accumulating fatigue, strength endurance was developed. This ability was further developed in the upper limbs through interval endurance on the rope, ladders or trapeze.

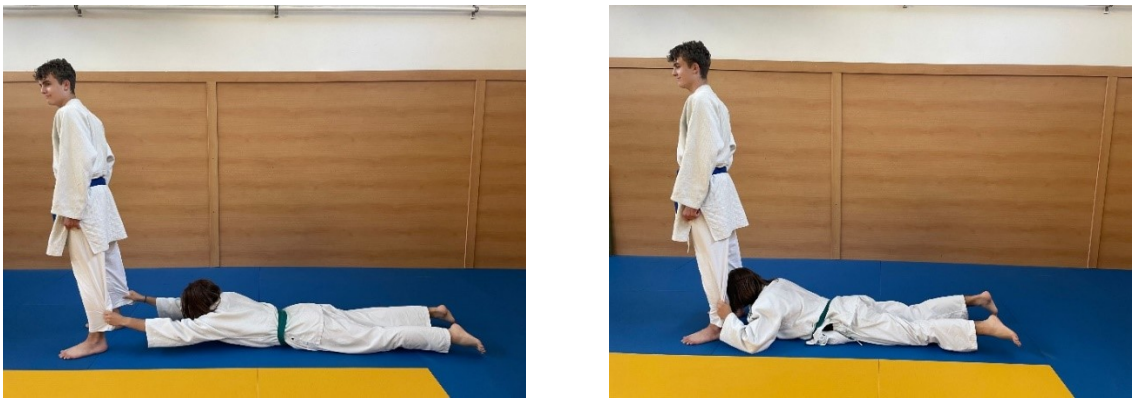
The end of the training belonged mainly to calming down the body and various compensatory and stretching exercises. During the final stretching together we focused especially on the strengthened parts. It was important to stretch especially the finger flexors and the forearm muscles, which are most involved in gripping the kimono. Proper stretching and subsequent rest leads to muscle recovery and the possibility of progressive strengthening in subsequent workouts.

Photos of selected exercises included in own training intervention

Fig 4: Pull-ups over the mat with ankle hold

Source: own

Fig. 5: Pull-ups over the mat with holding onto the pant legs



Source: own

Fig. 6: Pull-ups over the mat with holding the sleeves

Source: own

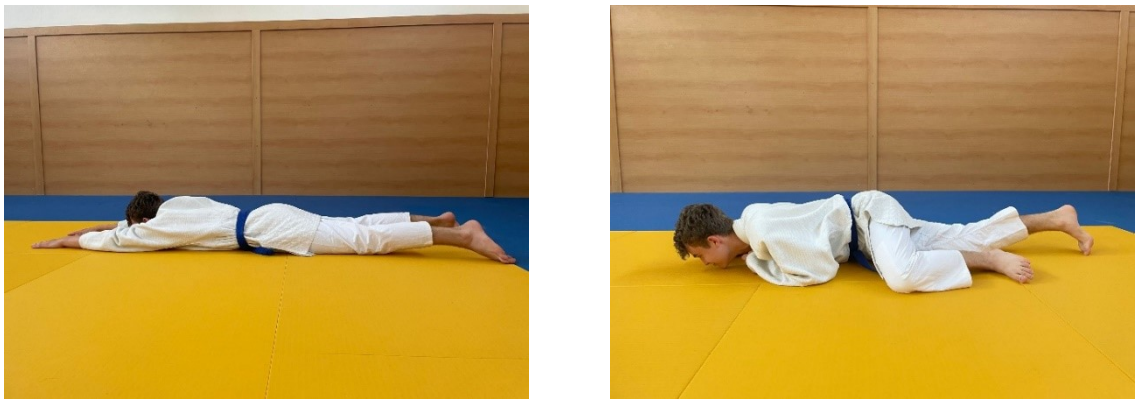
Fig. 7: Pull-ups with using the belt

Source: own

Fig. 8: Exercises using specific sleeve grips (left) or collar grips (right)

Source: own

Fig. 9: Different forms of crawling over the mat



Source: own

Fig. 10: Exercises using a kimono on a trapeze bar– hanging, pull ups, or endurance in hanging

Source: own

Statistical data processing

Statistical evaluation of hypotheses was performed in RStudio (version 2023.03.0+386, R version 4.2.3).

Multiple statistical tests were used for efficient statistical decision making. The Shapiro-Wilk's auxiliary test was used to test the normality of the data. Paired tests were applied when comparing two dependent groups. If normality was rejected in at least one group, the non-parametric two-sample Wilcoxon test was used (Hendl, 2015).

The test of difference between three or more independent groups was applied to test for differences by three age categories. Fisher's exact test was used to evaluate the dependence of the data in the contingency table.

Research investigation

The first research question compared the change recorded in the hand dynamometry test between *the forearm position in extension and the 90-degree flexion position in supination.* We tested both in terms of absolute change recorded and, for control, relative change.

Graph 1: Scatter plot comparing the values from the two tests between the dominant arm (red) and the non-dominant arm (blue)

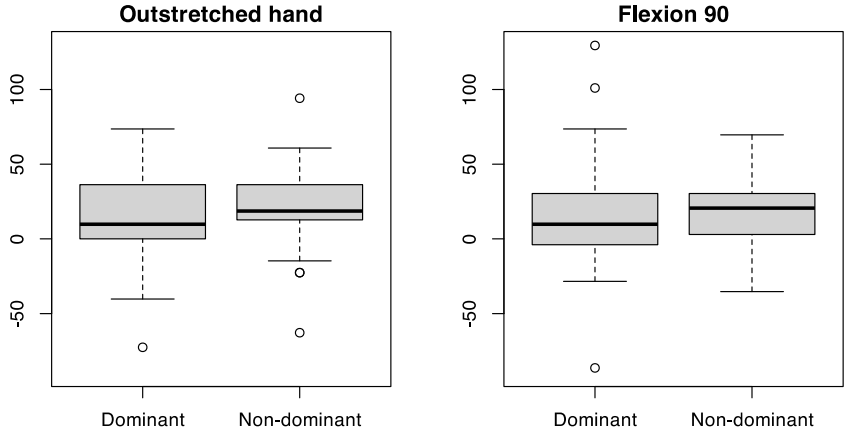
Source: own

Graph 1 provides a basic overview of the measured data. One point is shown for each proband, the coordinates of which are *the value of the first test and the value of the second test.* If the point lies above the dashed line, there has been an improvement; if it lies below the dashed line, there has been a downgrade. From the graph we can observe red points (dominant hand) and blue points (non-dominant hand). At first glance, there is no significant difference between these points, but a significant number of points are above the dashed line, indicating an upgrade in performance.

The testing section, where we assess whether the difference in changes is statistically significant, is presented in the last two columns of Table 2. The column labelled 'p_n value' contains the result of the Shapiro-Wilk normality test. Since we do not reject normality in either case, we subsequently use a paired t-test to compare the differences in changes on the dominant and on the non-dominant hands.

When evaluating the composite hypothesis (i.e., for the outstretched hand and Flexion 90 combined) using the Bonferroni correction, it is not possible to reject the null hypothesis of equal expected values of changes because none of the p-values is lower than 0.025.

Graph 2: Boxplots of changes achieved between dominant and non-dominant hands



source: own

Tab. 2: Sample characteristics of changes by dominance and results of testing for differences.

Test	Characteristics of changes						p_n value	p value
	Count	Mean	Median	Minimum	Maximum	SD		
Hand outstretched								
Dominant	37	14.6	9.8	–72.6	73.6	28.6	0.257	0.043*
Non-dominant	37	22.3	18.6	–62.8	94.2	27.7		
Flex 90								
Dominant	37	15.9	9.8	–86.3	129.5	38.3	0.416	0.957
Non-dominant	37	16.3	20.6	–35.3	69.7	26.7		

Note: In the column labelled "p_n value," the result of the normality test for the data is provided. Normality was not rejected in either case, so the "p value" column contains the result of the paired t-test.

Another perspective on the obtained results is in terms of relative change. The data and results of statistical tests are presented in Table 3.

From the results in the column labelled 'p value', it is evident that in separate hypothesis testing, we could reject the null hypothesis for the outstretched hand and accept the alternative that the medians of relative differences on the dominant and on the non-dominant hands are different. However, in this case, a higher relative increase (8.1%) is observed in the non-dominant hand compared to the dominant hand (4.7%).

When evaluating the composite hypothesis (i.e., for the outstretched hand and Flexion 90 combined) with the use of Bonferroni correction, we could reject the null hypothesis of equality and accept the alternative that relative changes differ between the dominant and non-dominant hands (at least one p-value is lower than 0.025).

Table 3: Sample characteristics of relative changes by dominance and results of testing for differences.

Test	Characteristics of changes						p_n value	p value
	Count	Mean	Median	Minimum	Maximum	SD		
Hand outstretched								
Dominant	37	4.7 %	3.7 %	–25.3 %	23.6 %	9.1 %	0.011*	0.020*
Non-dominant	37	8.1 %	7.7 %	–24.0 %	45.1 %	10.8 %		
Flex 90								
Dominant	37	5.1 %	3.1 %	–32.1 %	37.0 %	12.5 %	0.818	0.701
Non-dominant	37	5.9 %	6.0 %	–12.1 %	31.8 %	10.3 %		

Note: In the column labelled "p_n value," the result of the normality test for the data is provided. For the outstretched hand, normality is rejected, and the "p value" column contains the result of the paired Wilcoxon test. For flexion, the result of the paired t-test is provided.

The hypothesis that the change in the dominant hand would be statistically significant compared to the non-dominant hand was not supported in either view, and so the hypothesis that the dominant hand would show a greater improvement than the non-dominant hand could not be supported. Conversely, a statistically significant change was shown for the outstretched hand test in favour of the non-dominant hand, where a more significant relative improvement was noted. These results may indicate that the subjects had a naturally stronger dominant UL, as evidenced by the resulting mean test value of 335 N versus 317.5 N on the non-dominant side. Thus, the resulting improvement was more pronounced on the non-dominant UL side in both the flexion 90 test and especially the outstretched hand test. For the last test (rope 1 min) when comparing groups, we will convert values into categories: downgrade, stagnation, and upgrade. This approach helps us avoid issues with expressing percentages, especially when we cannot calculate them for zero initial values. An overview of the values is provided in Table 4. To test whether there is a statistically significant association between age groups and categories among the divided groups, we used Fisher's exact test. The resulting p-value is 0.891, and we cannot reject the hypothesis of independence between age groups and categories.

Table 4: Categories of change for the rope test (1 min) by age group.

Group	Number in categories			Percentage of		
	Down grade	Stagnation	Upgrade	Down grade	Stagnation	Upgrade
10–11 years	0	1	2	0 %	33 %	67 %
12–13 years	1	6	14	5 %	29 %	67 %
14–15 years	1	2	10	8 %	15 %	77 %

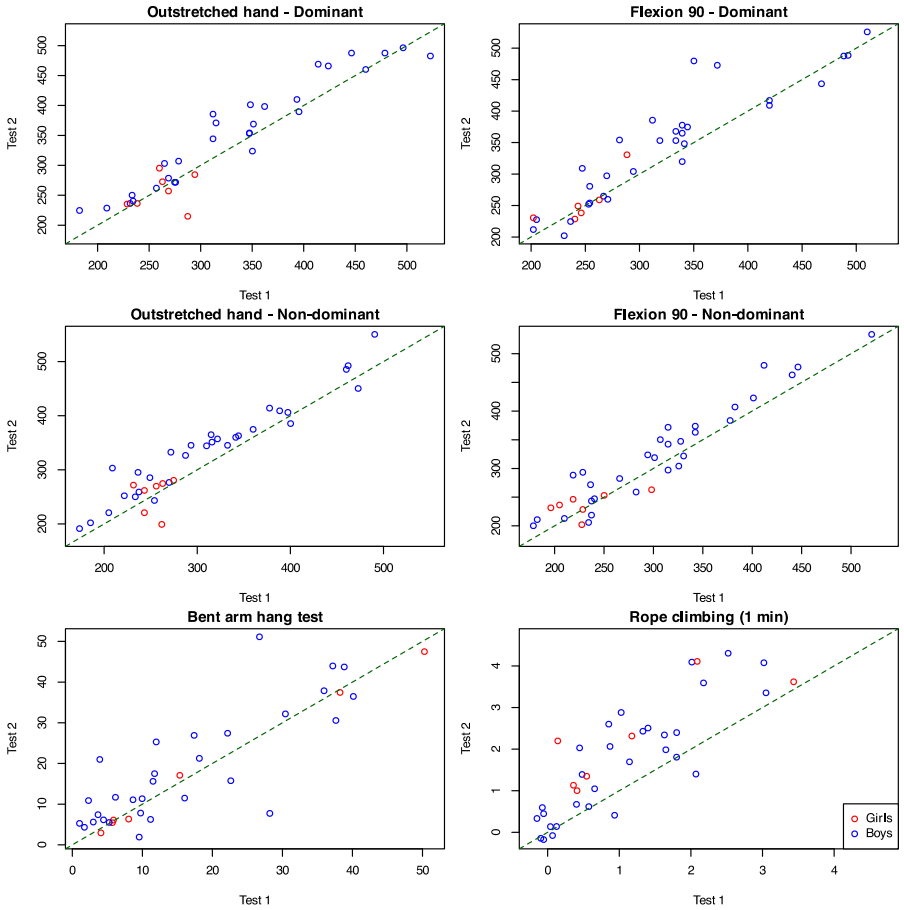
4. DISCUSSION

We found differences in the results of only two manual dynamometry tests - *hand outstretched* on the non-dominant side and *flexion 90* on the non-dominant side. Since in the post-hoc tests performed in these two cases the difference was always identified only between the 10-11 years category and the others, and we have only three probands in the 10-11 years category, we cannot give too much weight to the conclusions. However, this finding can serve for further observation with multiple groups and can be the basis for the development of maximal grip strength already in this age group.

We tested the results leading to the second research question from two perspectives. In the first, we focused on the difference test. Here, however, the results could be influenced by the fact that the initial values of the two groups often differ. So in the second part we compared the relative difference, i.e. by how much the initial value changed in both groups.

Graph 3 serves as a basic overview of the data and contains one point for each proband, the coordinates of which are *the value of the first test and the value of the second* test. If the point lies above the dashed line, there has been an improvement; if it lies below, there has been a deterioration. The graph does not suggest that the red points (girls) and the blue points (boys) differ in any significant way in the degree of improvement.

Graph 3: Scatter plot comparing values from the two tests between girls (red) and boys (blue)



Source: own

While the results suggest that there could be statistically significant differences between boys and girls, since there were only seven representatives in the girls' group, the statistical tests are not very powerful and could only detect a significant difference. In the future, it would be advisable to focus on obtaining more data from the girls and to perform the testing again, where especially the differences between the girls' and boys' results in the bending endurance test indicate interesting values for further research.

5. CONCLUSION

In the judo environment we lack work dedicated to the development of specific grip strength, which is so important in this sport. In judo as a combat sport there are still more boys than girls, which has led to a slight bias in the results and certainly further re-testing with a larger group of girls would be appropriate. Overall, after completing the training program, there was an average improvement for boys in all tested indicators. In the group of girls, on the other hand, there was a slight downgrade in three tests, which indicates to us different parameters and strength development compared to boys already in these age categories.

When comparing the performance of the dominant and non-dominant hand in the hand dynamometry tests, we observed a statistically significant change in the outstretched hand test in favour of the non-dominant hand. However, this

statistical significance has not been demonstrated by other studies such as Štefanovský (2015); Ache Dias et al. (2012); or Štefanovský, Durmis and Kraček (2018).

Moreover, Ache Dias et al. (2012) also found no significant differences in the hand dynamometry test between highly trained Brazilian judokas and non-judokas. However, the effect of judo training on the level of handshake fatigue was demonstrated.

Štefanovský (2015) focused his research on comparing the maximum grip strength of the dominant hand when testing 11-year-old boys training taekwondo (176.6 N), judo (189.3 N) and karate (200.1 N). Thus, the karate group obtained the highest mean values from this study. However, in comparison with our results for the U12 age group, the judokas tested by us clearly dominate, having improved their average value of 257.3 N for the outstretched hand test and even 263.9 N for flexion 90.

In the 1-minute rope climb test we can see the limiting factor in again the proband's weight and gravitational force, but also in the use of the legs in the climbing technique. Thus, individuals who could also use their feet better to assist in climbing were more likely to achieve a better result. However, without the necessary upper limb strength, even this skill is not enough. Of the 37 probands, a total of 26 individuals, regardless of age or gender, were able to improve since initial testing, and only 2 individuals have gotten worse over the preparation period.

A specific focus on grip strength in judoka could also be a benefit of this research investigation. The issue of grip strength has not received much attention in the theoretical and practical aspects of contemporary judo, although it is one of the fundamental aspects of performance.

The results can be used not only in the grappling setting for further extension and validation of significance with the involvement of a much larger number of probands. We believe that the attached movement intervention will also serve as inspiration for the development of upper limb grip strength not only for judo coaches and will provide some impetus for more research and testing related to grip technique and strength.

6. LITERATURE

Ache Dias, J., Wentz, M., Kulkamp, W., Mattos, D., Goethel, M. & Borges Júnior N. (2012). Is the handgrip strength performance better in judokas than in non-judokas? *Science & Sports*, 27(3). ISSN 07651597. Dostupné z: https://doi.org/10.1016/j.scispo.2011.10.005

Buriánek, A. (2018). *Sledování rozdílů úchopové síly při různém posturálním zajištění*. Plzeň. Bakalářská práce. Západočeská univerzita v Plzni, Fakulta zdravotnických studií.

Čuta, M. & Vážná, A. (2021). Síla stisku ruky u sportovních gymnastek. *Anthropologia integra* [online]. 12(2), 29-33 [cit. 9.6.2023]. ISSN 1804-6665. Dostupné z: https://doi.org/10.5817/AI2021-2-29 .

Došla, J. & Meško, J. (2015). Silové schopnosti a jejich vliv na sportovní výkon v lezení. *Studia sportiva* [online]., 9 (1), 45-53 [cit. 14.6.2023]. Dostupné z: https://doi.org/10.5817/StS2015-1-6.

Dovalil, J. et al. (2009). *Výkon a trénink ve sportu*. 3. vyd. Praha: Olympia, 331 s.

Havel, Z. & Hnízdil, J. (2009). *Rozvoj a diagnostika silových schopností*. Ústí

nad Labem: Univerzita J. E. Purkyně v Ústí nad Labem.

Hendl, J. (2015). *Přehled statistických metod: analýza a metaanalýza dat*. Praha: Portál.

Hohmann, A., Lames, M. & Letzelter, M. (2010). Úvod do sportovního tréninku. Prostějov: Sport a věda.

Choutka, M. a Dovalil, J. (1991). *Sportovní trénink*. Praha: Olympia.

Krstulović, S., Maleš, B., Žuvela, F., Erceg, M. & Miletić, Đ. (2010). Judo, soccer and track-and-field differential effects on some anthropological characteristics in seven-year-old boys. *Kinesiology* [online]. 42(1), 56-64 [cit. 15.6.2023]. Dostupné z: https://www.researchgate.net/publication/228662585_Judo_soccer_and_track-and-field_differential_effects_on_some_anthropological_characteristics_in_seven-year-old_boys.

Kučera, Miroslav, Kolář, Pavel a Dylevský, Ivan. (2011). *Dítě, sport a zdraví*. Praha: Galén.

Maestroni, L., Read, P., Bishop, Ch. & Turner, A. (2020). Strength and Power Training in Rehabilitation: Underpinning Principles and Practical Strategies to Return Athletes to High Performance. *Sports Medicine* [online]. 50(2), 239-252 [cit. 27.4.2023]. Dostupné z: doi:10.1007/s40279-019-01195-6.

Měkota, K. & Novosad, J. (2005). *Motorické schopnosti*. Olomouc: Univerzita Palackého.

Perič, T. & Dovalil, J. (2010). *Sportovní trénink*. Praha: Grada.

Ružbarská, Ingrid a Turek, Milan. (2007). *Kondičné a koordinačné schopnosti v motorike detí predškolského a mladšieho školského veku*. Prešov: Prešovská univerzita, Fakulta športu.

Štefanovský, Miloš. (2015). *Fyziologické, motorické a somatické charakteristiky džudistov z hľadiska veku a úrovne trénovanosti*. Bratislava: Slovenská vedecká spoločnosť pre telesnú výchovu a šport.

Štefanovský, Miloš, Durmis, Ján a Kraček, Stanislav. (2018). *The hand-grip strength of young cobat sports athletes. In: ÚPOLY v minulosti a v súčasnosti: Zborník z medzinárodnej vedeckej konferencie*. Bratislava: ICM Agency [online], s. 1-12 [cit. 15.6.2023].

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VERIFICATION OF THE EFFECT OF AN EXERCISE PROGRAMME USING WALKING AND DIET ADJUSTMENT IN HYPERTENSION

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Abstract

One of the leading risk factors for cardiovascular disease is hypokinesis. Therefore, an exercise regimen is emphasized for the prevention and control of hypertension, while at the same time aiming to reduce overall cardiovascular risk in addition to achieving normal blood pressure values.

The study aimed to verify the effect of an exercise programme using walking and dietary modification on the reduction of blood pressure values in hypertension, while the effect of the intervention on weight reduction and change in body composition was also studied.

The research method in our work was a case study. The proband was a physically inactive overweight woman, age 55 years, treated hypertensive, whose blood pressure at entry to the program reached the values of mild hypertension even with treatment. Baseline data were resting blood pressure values measured for 7 days in the morning and evening, a two-day record of physical activity, a seven-day record of diet, diagnosis and analysis of body composition with the InBody device, and calculation of the WHR index. The proband developed a physical activity intervention program using walking for 12 weeks, a minimum of 5 times per week, at moderate intensity, with a gradual increase in daily walking time from 30 to 60 min/day. As an adjunct to the exercise intervention, she was recommended a dietary modification. At the end of the follow-up period, blood pressure values were measured in the same way, a diagnostic and body composition analysis was performed with the InBody device, and the WHR index was calculated. The intervention program was also evaluated in relation to overweight and body composition as important factors in hypertension.

After 12 weeks of the intervention programme, the mean reduction in systolic blood pressure was 6,29 mmHg in the morning and 4,86 mmHg in the evening. The average reduction in diastolic blood pressure was 4,57 mmHg in the morning and 3,14 mmHg in the evening. There was also a decrease in heart rate by an average of 4,07 beats per minute. At the same time, the intervention program led to a reduction in the proband's body weight (by 7,2 kg), a decrease in BMI (from 27,8 to 25,5 kg/m2), a decrease in body fat percentage (by 3,9 %) and a decrease in WHR index (from 0,91 to 0,88).

These results confirmed that regular physical activity and dietary modification play an important role in the treatment of high blood pressure and verified the effectiveness of expert recommendations in hypertension. They also confirmed the positive effect of these recommendations on weight reduction and body composition. In summary, this work verified the beneficial effects of walking supported by dietary modification on the following risk factors for cardiovascular disease - high blood pressure, overweight, body fat, and central obesity.

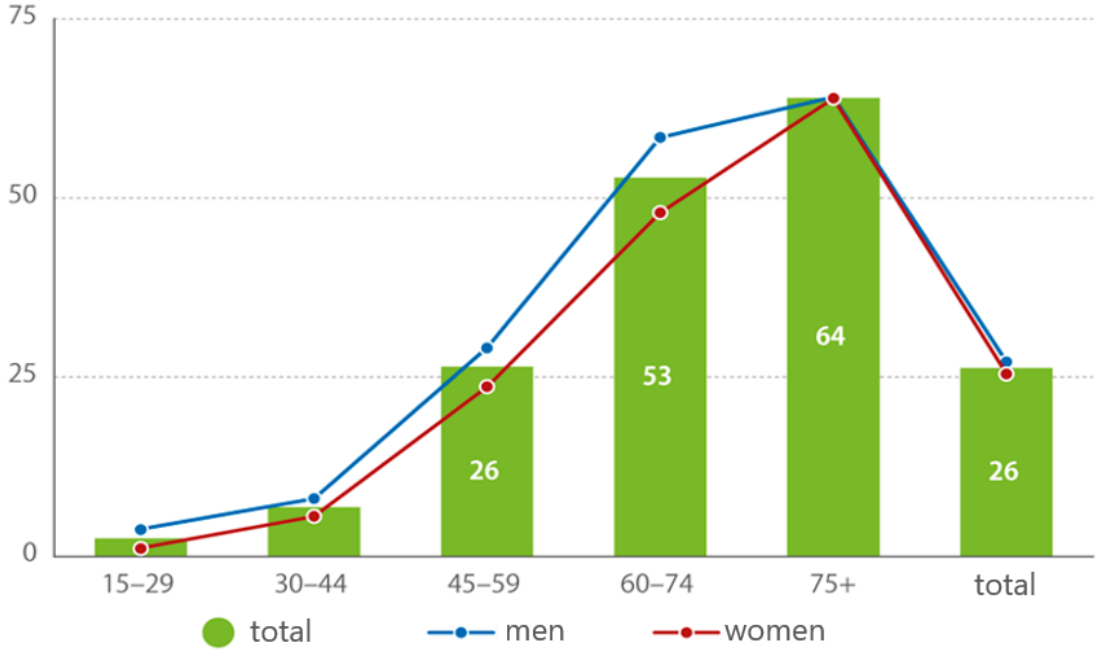
Keywords: *hypertension, blood pressure, walking, exercise intervention*

1. INTRODUCTION

Cardiovascular diseases are among the most common diseases and causes of death in developed countries today. Among the most common of these is hypertension, which is also one of the major risk factor for other cardiovascular diseases.

The prevalence of hypertension in the population of the Czech Republic is assessed in the European Health Interview Survey (EHIS), which is compulsorily conducted in EU countries once every six years. In the Czech Republic, it is conducted by the Institute of Health Information and Statistics of the Czech Republic (IHIS CR) together with the Czech Statistical Office (CSU), most recently in 2019. The EHIS results show, among other things, that hypertension is the most common chronic disease in the Czech Republic. As can be seen in Figure 1, hypertension affects more than a quarter of the population, its prevalence increases significantly with age and is more common in men (27% in men and 25% in women), with the exception of the over-75 group, in which women and men are equally represented (Pištorová, 2021).

Figure 1: Percentage of people with hypertension in the Czech Republic in 2019

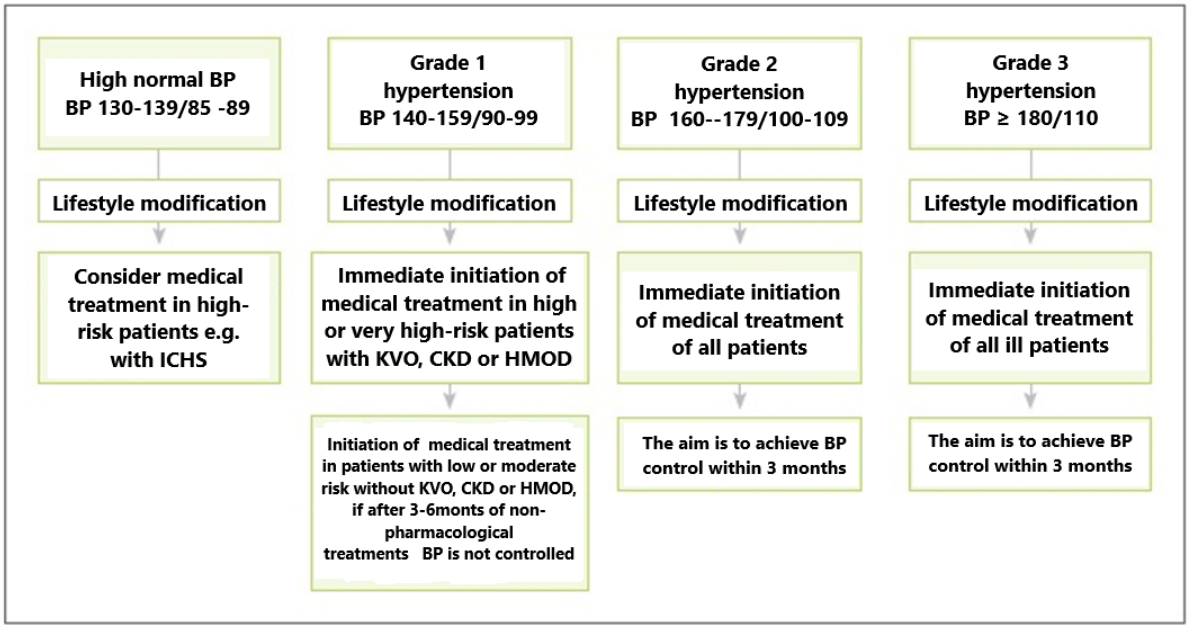


source: Pištorová, 2021

As far as the development of hypertension in the Czech Republic is concerned, blood pressure values in our population have decreased significantly over the last 30 years. In addition to improvements in the pharmacological treatment of hypertension, this is also due to improvements in dietary habits in terms of reduced consumption of salt and saturated fat. In fact, blood pressure has fallen even in people who have not been treated pharmacologically (Widimsky, 2019).

The principles of initiating antihypertensive treatment are summarized in Figure 2. Lifestyle modification is recommended for all patients with high blood pressure and also for those with high normal blood pressure. In grade 2 and 3 hypertension, pharmacological treatment is initiated immediately. In grade 1 hypertension and in high normal blood pressure, pharmacological treatment is indicated depending on the level of risk determined by the SCORE tables and the presence of cardiovascular disease and organ damage (Cífková, 2018).

Fig. 2: Initiation of antihypertensive treatment



Initiation of antihypertensive treatment (lifestyle modification and medical therapy) at different BP values measured in the office

CKD - chronic kidney disease HMOD - hypertension-mediated organ damage;
ICHS - ischaemic heart disease; CVD - cardiovascular disease; BP - blood pressure

source: Cífková, 2018

Non-pharmacological treatment of hypertension consists of regimen measures including physical activity, adherence to nutritional measures (including limitation of salt intake and alcohol consumption), weight reduction, smoking prohibition and avoidance of blood pressure-raising drugs (Koudelka and Sovová, 2018). Last but not least, efforts to limit the influence of stress are important, as it can significantly increase blood pressure (Psalmanová, 2017). Sleep hygiene also plays a role in the treatment of hypertension (Novák and Plačková, 2012).

Physical activity recommendations are mainly focused on aerobic physical activities. It has been shown in many studies that people who perform some regular physical activity have a significantly lower risk of cardiovascular disease (24% for men and 27% for women) than people who do not perform any activity (Mikeš and Tuka, 2020). In hypertensives, physical activity reduces the risk of cardiovascular complications both directly, by lowering resting and exercise blood pressure values, and indirectly by affecting other risk factors for cardiovascular disease, through weight reduction, increased glucose tolerance, improved lipid profile, reduced stress, or reduced probability of smoking (Štejfa, 2007).

The simple fact that physical activity has a positive effect on mood and leads to psychological relaxation cannot be overlooked, so in people in whom psychology plays a role in the development of hypertension (stress, suppressed anger, conflict avoidance, etc.), it may have a secondary effect on lowering blood pressure by affecting emotional state.

The major health organisations that deal with the relationship between physical activity and cardiovascular disease, including hypertension, such as the American College of Sports Medicine (ACSM), the European Society of

Cardiology (ESC) and the Czech Society of Cardiology, follow the Guidelines for Physical Activity in the Population, published by the US Department of Health and Human Services in 2018. The American College of Sports Medicine (ACSM) recommends aerobic exercise for people with hypertension at a frequency of 5-7 times per week (with the possibility of supplementing with weight training with a lower load 2-3 times per week). The frequency of physical activity is recommended for most days of the week, because in addition to the effect of aerobic exercise on the drop in blood pressure with long-term exercise, there is also an immediate effect, persisting up to 24 hours. Its intensity should be moderate (i.e. 40-60% of VO2max or Borg scale level 11-14) and its duration 30-60 min, either continuous or intermittent, with each exercise lasting at least 10 min. Regarding the type of aerobic exercise, prolonged rhythmic physical activities using large muscle groups such as walking, cycling, swimming are recommended. At the same time, the progression of the exercise program should be gradual in hypertonic patients, especially in terms of intensity (Zaleski, 2019).

The European Society of Cardiology (ESC) recommendations on non-pharmacological treatment and prevention of cardiovascular diseases from 2021 are comparable. The Czech Society of Cardiology has also adopted them for its recommended practices. These recommendations include moderate-intensity aerobic physical activity for 150-300 minutes per week, or intense aerobic physical activity for 75-150 minutes, or a combination of both, spread throughout the week, such as walking, jogging, cycling, etc. Activity spread over smaller (at least 10-minute) periods also helps to reduce sitting time. If some individuals are unable to follow these recommendations due to age, other illnesses or other limitations, they should be as physically active as their abilities and conditions allow. For people with low levels of physical fitness, a gradual increase in the level of physical activity is recommended. Intensity should be assessed in relative terms (e.g., using the Borg scale), as persons with low physical fitness must exert more effort to perform the same physical activity than more fit persons (Visseren et al., 2021; Vrablík et al., 2022).

The U.S.Federal Guidelines (Physical Activity Guidelines Advisory Committee Report, 2008) suggest that an exercise volume of 500–1,000 MET·min/week (MET equivalent of PA × number of minutes) is optimal and can be achieved, for example, with 150 min/week of walking at 6.4 km/h (intensity of 5 METs) or 75 min of jogging at 9.6 km/h (10 METs). It seems to me more flexible to express recommendations of exercise in MET.min /week than in minutes/week.

It is important to include activities in the exercise programme that do not interfere too much with the daily routine, at least initially, and that the patient will enjoy or at least not be averse to, because such activities will be easier to maintain in the long term. From this perspective, walking, which is also accessible and safe, seems ideal.

Isometric physical activities such as lifting and carrying loads, mowing the grass, digging in the garden, etc. are not suitable for hypertensive patients (Widimský, 2019). Hypertonic people should avoid strength sports (lifting heavier loads, weightlifting, wrestling, bodybuilding), as the contraction of large muscle groups increases resistance in the vasculature and thus blood pressure; competitive sports are also not suitable because of the psychological upset (Hošková, 2012).

In patients with controlled hypertension and with high normal blood pressure, the recommended physical activity can be

started without stress testing; in patients with stage 2 hypertension or in patients who have already suffered organ damage (heart, retina, kidneys), stress testing is advisable. If a patient with hypertension has any serious associated disease, it is advisable to consult the treating physician regarding physical activity. Absolute contraindications to physical activity in hypertensive patients are acutely decompensated hypertension (BP > 180/110 mmHg), fresh myocardial infarction, complete conduction disorder, acute heart failure, unstable angina and, of course, any other acute illnesses (Mikeš and Tuka, 2020).

Dietary measures also play an important role in hypertension. Firstly, because of its direct effect on blood pressure, and secondly, because of its influence on the risk of cardiovascular complications of hypertension, as dietary intake also affects other risk factors for atherosclerosis. In addition to lowering blood pressure, it helps to reduce overall body weight, normalize blood lipid and blood sugar levels and reduce susceptibility to thrombosis (Cífková, 2005).

Important in hypertension is the reduction of dietary sodium intake, i.e. salt (sodium chloride) restriction. The recommended daily intake of salt is 5 g (this corresponds to about 2 g of sodium); in hypertensives, salt consumption per day should not exceed 4 g. It is not enough to limit the use of table salt, it is also necessary to significantly reduce or eliminate foods containing salt, such as sausages and many other processed foods (Kužela and Patlejchová, 2003). In hypertensive patients, the consumption of fats, or saturated fatty acids that increase blood cholesterol levels, which is the main component of sclerotic plaques, should also be significantly reduced (Sovova, 2008). It is desirable to limit red meat, which contains a lot of fat with saturated fatty acids. On the other hand, the consumption of good quality oils with a high content of unsaturated fatty acids is recommended, as well as the consumption of fish, as it contains the so-called omega-3 fatty acids, which have an anti-sclerotic effect. In addition to the anti-sclerotic effect, restriction of fat consumption also leads to a reduction in total energy intake and consequently to a reduction in body weight, which is another important dietary measure in obese or overweight patients (Kužela and Patlejchová, 2003).

Alcohol restriction is essential for people with hypertension, as immoderate alcohol consumption increases systolic and diastolic blood pressure - expert recommendations limit alcohol consumption to 14 units per week for men and 8 units per week for women, where one unit is defined as 250 ml of beer or 125 ml of wine (Widimský, 2019).

Consumption of a larger amount of dietary fibre, which is antisclerotic, is advisable. Water-soluble fibre (pectins, beta-glucans) lowers cholesterol levels both by preventing the reabsorption of cholesterol in the small intestine and, once broken down in the large intestine, is partially absorbed and then reduces cholesterol production in the liver. Water-insoluble fibre (cellulose, hemicelluloses, lignin) reduces the reabsorption of bile acids in the small intestine, and the newly formed acids are then formed from cholesterol, resulting in a reduction in blood cholesterol levels. It also plays a role in weight loss as it reduces the feeling of hunger. The daily intake of dietary fibre should be 25-30 grams and the ratio of soluble to insoluble fibre should be 1:3. In our population, the daily fibre intake is only 10-15 grams (Suchánek, 2013).

In the context of the diet for high blood pressure, the so-called DASH diet (Dietary Approaches to Stop Hypertension) is sometimes referred to, in which mainly fruits, vegetables and fish are represented

and animal fats and cholesterol are limited. Studies have shown the effect of this diet on lowering blood pressure values and reducing cardiovascular complications and overall mortality (Widimsky, 2019).

Overview of available studies focused on the effect of physical activity

Lee et al. (2021) conducted a large meta-analysis to evaluate the effect of walking on blood pressure and heart rate. They included a total of 73 studies with hypertensive and normotensive participants of both sexes aged 16 to 84 years that evaluated the effects of an intervention program using walking on blood pressure values and on heart rate. Walking was of moderate intensity, most commonly brisk walking in the countryside or in the city, and in a few studies treadmill, Nordic walking or stepper walking, and the intervention programme lasted on average 15 weeks (most commonly 12 to 15 weeks). The frequency and duration of walking was 20-40 minutes 3-5 times per week, with an average of 153 minutes per week (most commonly 150 to 180 minutes). In the results of this meta-analysis, then, the decrease in systolic blood pressure values averaged 4.11 mmHg (73 studies included), the decrease in diastolic blood pressure values averaged 1.79 mmHg (69 studies included), and heart rate decreased by an average of 2.76 beats per minute (26 studies included). In the conclusion of this paper, the authors summarize that walking can reduce both systolic and diastolic blood pressure, regardless of age, gender, or baseline blood pressure.

Oja et al. (2018) reached almost identical results in their paper. Their meta-analysis included 37 studies lasting at least 8 weeks, with a total of 2001 adult inactive healthy participants, and the intervention exercise program consisted of normal walking for thirty studies, and the other was treadmill walking or Nordic walking. In the results, the decrease in systolic blood pressure values was 4.05 mmHg and the decrease in diastolic blood pressure values was 1.76 mmHg.

Another meta-analysis by de Barcelos et al. (2022) also confirmed that aerobic physical activity reduces systolic and diastolic blood pressure in adults with hypertension. Twenty-four studies lasting at least six weeks were selected, with 12 studies including an intervention exercise program with progression in intensity, frequency and/or duration and 12 studies an intervention exercise program without progression. The total number of participants in the studies was 1207, and these were men and women aged 37-73.5 years with hypertension; in 11 studies, participants were treated with antihypertensive. The most common aerobic physical activity in the studies was stationary bicycle riding, walking and running, the length of the intervention program ranged from 6 to 37 weeks and individual exercise sessions lasted 20-60 minutes with a frequency of 3-4 per week. After aerobic training with progression, there was a decrease in systolic blood pressure values by an average of 10.67 mmHg and diastolic blood pressure values by an average of 5.49 mmHg. After aerobic training without progression, there was a decrease in systolic blood pressure values by an average of 10.17 mmHg and diastolic blood pressure values by an average of 6.51 mmHg. In their conclusions, the authors of this paper summarize that aerobic physical activity can reduce systolic and diastolic blood pressure in adults with hypertension. While there is almost no difference in blood pressure reduction with and without exercise progression, it is apparent when examining individual studies that greater reductions may occur with progression in intensity and even more so in duration. The authors also mention in their conclusions the association of older age and greater blood pressure reduction.

For example, Fu et al. (2022) reached similar results to a previous meta-analysis,

including 14 studies with a total of 1027 hypertensive patients aged 35 years or older and duration of aerobic training ranging from 4 to 20 weeks (most commonly 12 weeks). The aerobic physical activity here was most commonly walking, running, cross-country skiing, and stationary biking. The duration of exercise ranged from 20 to 60 minutes and its frequency was 3 times per week. As a result of aerobic training, the values of systolic blood pressure decreased by an average of 9.91 mmHg and diastolic blood pressure by an average of 4.32 mmHg.

In their study, Blumenthal et al. (2000) investigated the effect of exercise on high blood pressure in addition to the effect of weight loss. The six-month study involved 133 adults with high normal blood pressure and with grade 1 to 2 hypertension, sedentary lifestyle and overweight. The authors focused on assessing the effects on high blood pressure of aerobic physical activity alone and aerobic physical activity combined with a weight loss intervention program consisting of dietary modification and change in eating behaviour. Both the exercising group and the exercising while losing weight group showed a reduction in blood pressure at the end of the study, however, the combined program group showed a greater reduction, with a 7 mmHg reduction in systolic blood pressure and a 5 mmHg reduction in diastolic blood pressure for the aerobic physical activity combined with the weight loss intervention program. For aerobic physical exercise alone, there was a reduction in systolic pressure of 4 mmHg and diastolic pressure also by 4 mmHg.

The aim of the study by Moreau et al. (2001) was to assess the effect of walking on blood pressure values in 24 postmenopausal women aged 53-55 years with high normal blood pressure or grade 1 hypertension. After a 12-week intervention program using walking, systolic blood pressure values decreased by an average of 6 mmHg, while no significant decrease was observed in diastolic blood pressure. Reductions occurred in both untreated women and women taking antihypertensives.

2. AIM OF THE WORK AND RESEARCH QUESTIONS

The aim of the study was to test the effect of an exercise programme using walking and dietary modification in hypertension.
Research questions:

- Will the proband (she) with hypertension have a reduction in systolic blood pressure when regular walking is included according to the conditions set by the exercise intervention programme, and if so, how?
- Will the proband (she) with hypertension have a reduction in diastolic blood pressure with the inclusion of regular walking under the conditions of the exercise intervention programme, and if so, how?
- Will the proband's (her) adherence to recommendations for hypertension, such as the inclusion of regular physical activity and dietary modification, result in a reduction in excess weight and a change in body composition?

3. METHODOLOGY

The research method used in this study was a case study. The study was conducted between June and October 2022.

Baseline:
The proband was a postmenopausal woman aged 55 years. Her height was 177 cm and she stated a body weight of 87 kg at the initial interview. She had been diagnosed with hypertension about 20 years ago and had been treated pharmacologically since the beginning, taking an ACE inhibitor drug in the morning. She did not particularly follow the recommended regimen for

hypertension, had little exercise and was overweight. None of her family members had been treated for hypertension.

In the last year or so, the proband had observed, despite adherence to the prescribed medication, that when her blood pressure was measured in the morning with a home tonometer before taking her medication, her blood pressure was sometimes higher than before. She was told by her physician that she needed to follow the regimen, and this led her to request admission to the intervention program that was the subject of this study. She realised that she should, above all, incorporate exercise into her regime and that she could also improve her diet, in addition, she was beginning to perceive ageing in herself. Therefore, she would like to use the programme to help her initiate and implement a change that would be beneficial to her overall health.

The proband had a sedentary job that included working with clients, which was sometimes stressful. She commuted to work partly by car and partly by public transport, 3 times a week, the walk from the tram to work was about 400 m, after work, she usually went shopping or immediately home. The rest of the days she worked from home. She lived alone, in an apartment, and used the elevator. With friends, she went for a walk or to sit together occasionally, sometimes on an undemanding trip and about once or twice a year she went on a wellness stay or a not very demanding sightseeing holiday. She did not have a sporting attitude and did not engage in any regular physical activity. She had no physical limitations and felt healthy.

As for eating habits, the proband ate 3-4 times a day before the intervention, she prepared her own food, about 1-2 times a week she bought lunch or dinner in a restaurant or fast food or durable food to heat in the microwave. She liked sweet pastries, but tried not to eat too many. She would like to increase her fluid and fibre intake because of her diverticulosis of the colon, but she has not been very good at getting used to it. Her daily fluid intake was 1.5-2 litres (water, unsweetened tea), she did not consume alcohol, coffee only rarely. She did not smoke.

The proband was provided with a physical intervention programme supported by dietary modification, after which its effect on her blood pressure was evaluated. This programme was subsequently evaluated in relation to overweight and body composition as important factors in hypertension.

Diagnostic methods

Blood pressure measurement

Before and after the intervention program, the proband measured her blood pressure and resting heart rate at home with an Omron automatic digital oscillometric device for 7 days in the morning and evening.

Diagnosis and analysis of human body composition

Before and after the intervention program, the proband underwent a diagnostic and body composition analysis with the InBody device. This device works on the principle of bioimpedance, or the DSM-BIA method (direct segmental multi-frequency bioelectrical impedance analysis). The InBody measures many body parameters - the most important are total body weight, body fat, skeletal muscle, body water and minerals. It also diagnoses overweight and obesity by calculating BMI (Body Mass Index). It also determines the BMR (Basal Metabolic Rate).

WHR index

Waistline and hipline circumferences were measured before and after the intervention program. From the measurements, the WHR index was calculated, which indicates the distribution of fat in the body.

It assesses the type of fat distribution according to the WHR index:

	Rather peripheral	Balanced	Rather central	Central risk
Women	< 0,75	0,75-0,80	0,80-0,85	> 0,85
Men	< 0,85	0,85-0,90	0,90-0,95	> 0,95

(Komárek, 2007)

Recording of physical activity

At the first meeting, the proband was asked to observe and record her usual physical activity for 2 days. She was instructed to record all activity covering the entire 24 hours, indicating the type of physical activity and the exact duration of that activity. Based on the physical activity record, the proband's daily activity factor was determined, and the record also served, in addition to the information provided by the proband at the initial interview, to provide a more accurate picture of the proband's usual exercise habits and therefore her fitness.

The proband was provided with an indicative list of types of physical activities for her reference and use. Then, an activity factor was assigned to each type of physical activity in the proband's record, and a daily activity factor for a particular day was calculated, taking into account the duration of each activity.

Activity factors for specific physical activities:

1.1 BM sleep
1.2 BM lying awake (passive rest, TV, reading, etc.)
1.5 BM sitting and standing activity (reading, hygiene, dressing, cooking, eating, riding in transport)
3.0 BM moderate physical activity (housework, routine cleaning, laundry, walking 3-4 km/h, shopping, cycling up to 10 km/h)
5.0 BM low-intensity physical activity with little sweating (heavy cleaning, yard work, cycling up to 16 km/h, swimming breaststroke or 20 m/min mark)
8.0 BM physical activity with moderate intensity and moderate sweating (walking 7-8 km/h, heavier yard work, cycling up to 20 km/h, table tennis, volleyball)
10.0 BM physical activity with high intensity and high perspiration (running 15 km/h, swimming crawl, football, hockey, basketball)

(Seliger, 1974)

Dietary record

At the first meeting, the proband was asked to observe and record her usual diet for 7 days. She was instructed to record her diet in the Calorie Chart application, which is generally used to track energy intake and expenditure by recording foods consumed and physical activity. For the purposes of this thesis, the app was used to record a typical weekly diet before starting the intervention programme. The app depicts the caloric value of foods and the macronutrient and fibre content.

Intervention methods and procedures

Movement intervention

Based on the recommendations of the Czech Society of Cardiology, the European Society of Cardiology (ESC) and the American College of Sports Medicine

(ACSM), a physical activity programme was designed for the proband, and the assessment was set so that it would not be difficult for the proband and would not burden her in her daily life.

The duration of the intervention program, including baseline and outcome measures, was determined to be a total of 14 weeks, and walking was selected as the aerobic physical activity that the proband believed she would enjoy and be able to perform fully. Baseline measurements were taken in the initial week, followed by the actual exercise programme for 12 weeks, and exit measurements were taken in the final week.

The proband was recommended to walk a minimum of 5 times a week, with a moderate intensity assessed subjectively ranging from grade 10 to 14 on the Borg RPE scale, for 12 weeks, with a gradual increase in daily walking time every 4 weeks - as follows. Week 1 to 4 30 min/day (i.e. minimum 150 min/week), Week 5 to 8 45 min/day (i.e. minimum 225 min/week), Week 9 to 12 60 min/day (i.e. minimum 300 min/week). The walking time could be spread over several parts of the day, but one such part had to last at least 10 minutes.

Each day during the exercise programme, the proband recorded in a table the amount of walking time undertaken according to the conditions set out in the intervention programme, which was over and above her normal walking time. Contact was maintained with the proband throughout, the proband was motivated and the records were continuously checked.

Table 3 gives an overview of the duration of the physical activity by week. Of the 12 weeks, the proband met the prescribed duration in 10 weeks, in some of which she exceeded it, and in two weeks the duration of physical activity was less than recommended - in week 3 the total duration was 120 min/week (compared to the recommended 150 min/week) and in week 9 the total duration was 270 min/week (compared to the recommend 300 min/week).

Table 1: Duration of physical activity during the intervention programme

1. week	PA	2. week	PA	3. week	PA	4. week	PA
Date	min	date	min	date	min	date	min
10.7.	30	17.7.	30	24.7.	32	31.7.	31
11.7.	30	18.7.	34	25.7.	30	1.8.	30
12.7.	34	19.7.	28	26.7.	0	2.8.	32
13.7.	30	20.7.	39	27.7.	28	3.8.	30
14.7.	0	21.7.	40	28.7.	30	4.8.	0
15.7.	30	22.7.	0	29.7.	0	5.8.	30
16.7.	30	23.7.	0	30.7.	0	6.8.	16
total:	184	total:	171	total:	120	total:	169

5.week	PA
Date	min
7.8.	0
8.8.	0
9.8.	45
10.8.	47
11.8.	45
12.8.	46
13.8.	45
total:	228

6. week	PA
date	min
14.8.	0
15.8.	46
16.8.	46
17.8.	46
18.8.	45
19.8.	46
20.8.	0
total:	229

7. week	PA
date	min
21.8.	45
22.8.	45
23.8.	45
24.8.	0
25.8.	45
26.8.	45
27.8.	0
total:	225

8 week	PA
date	min
28.8.	46
29.8.	47
30.8.	45
31.8.	45
1.9.	0
2.9.	47
3.9.	0
total:	230

9 week	PA
Date	min
4.9.	60
5.9.	60
6.9.	60
7.9.	0
8.9.	60
9.9.	0
10.9.	30
total:	270

10. week	PA
date	min
11.9.	60
12.9.	60
13.9.	60
14.9.	60
15.9.	0
16.9.	40
17.9.	45
total:	325

11. week	PA
date	min
18.9.	60
19.9.	60
20.9.	60
21.9.	60
22.9.	0
23.9.	60
24.9.	0
total:	300

12. week	PA
date	min
25.9.	60
26.9.	0
27.9.	62
28.9.	62
29.9.	60
30.9.	60
1.10.	0
total:	304

Source: own

Nutrition intervention

To complement the exercise intervention, the proband was advised to change her diet for the duration of the intervention programme, ideally permanently.

Prior to the start of the intervention program, the proband tracked and recorded her usual diet in the Calorie Chart app for 7 days. Based on this record, the proband's average daily intake of kcal, protein, carbohydrate, fat, and fibre was determined. The average daily intake was 1826 kcal, B 86.7g, S 168.1g, T 86.5g, fibre 8.5g.

Since the intake came out lower than the output but the proband still did not lose weight, a possible variation of 15-20% was added to the intake. After this correction,

the value of daily energy intake was 2100-2191 kcal, which compared to the daily energy expenditure was already consistent with the proband not losing weight.

The dietary record also showed that the proband was not consuming enough fibre, her diet lacked fish and she was consuming a lot of processed foods, which are unsuitable for hypertension due to their high salt content.

A sample diet was prepared for the proband to give her an idea of how she could change her diet and also make it more varied. In this diet, the energy intake was reduced by 15 % to 1870 kcal/day and the macronutrients were changed as follows: 83 g protein, 51 g fat, 262 g carbohydrate. The diet was designed to meet the recommendations for people with hypertension and the choice of foods took into account the fact that the proband omits some foods from her diet due to diverticulosis of the colon. The proband was divided into four portions and was advised to always take her time, to consume the food calmly and to chew the food thoroughly.

In addition to the presentation of a sample menu, the proband was introduced to the general principles of healthy eating and the recommendations for hypertension that she should follow in her diet were emphasized:

- reduce the salt content of the diet to 2-3 g/day (also found in seasoning mixes) or, in the case of salt with reduced sodium content, to 5 g/day;
- season the diet with herbs and salt-free spices rather than salt;
- omit salty foods, various flavourings and processed foods with hidden salt, especially sausages or some cheeses;
- leave out semi-finished foods, instant foods and fast food;
- get enough fibre in the diet by eating fruit and especially vegetables;
- drinking at least 2 litres a day, unsweetened and non-carbonated drinks, mineral water is not suitable due to its sodium content;
- limit sweet as much as possible, can be replaced by a reasonable amount of fruit;
- limit fat consumption;
- use lean meat (chicken, turkey, rabbit, veal) and consume fish 2-3 times a week;
- use vegetable fats and good quality vegetable oils as fats;
- do not fry or add fat to food;
- process food by boiling, stewing, steaming, grilling, foil baking, hot air oven.

Results and discussion

Resulting comparison of input and output data

Blood pressure measurements

Table 2 compares the values of morning systolic and diastolic blood pressure measured before and after the end of the exercise intervention programme and these measurements are shown graphically in Figure 3.

Figure 3: Comparison of morning systolic and diastolic blood pressure

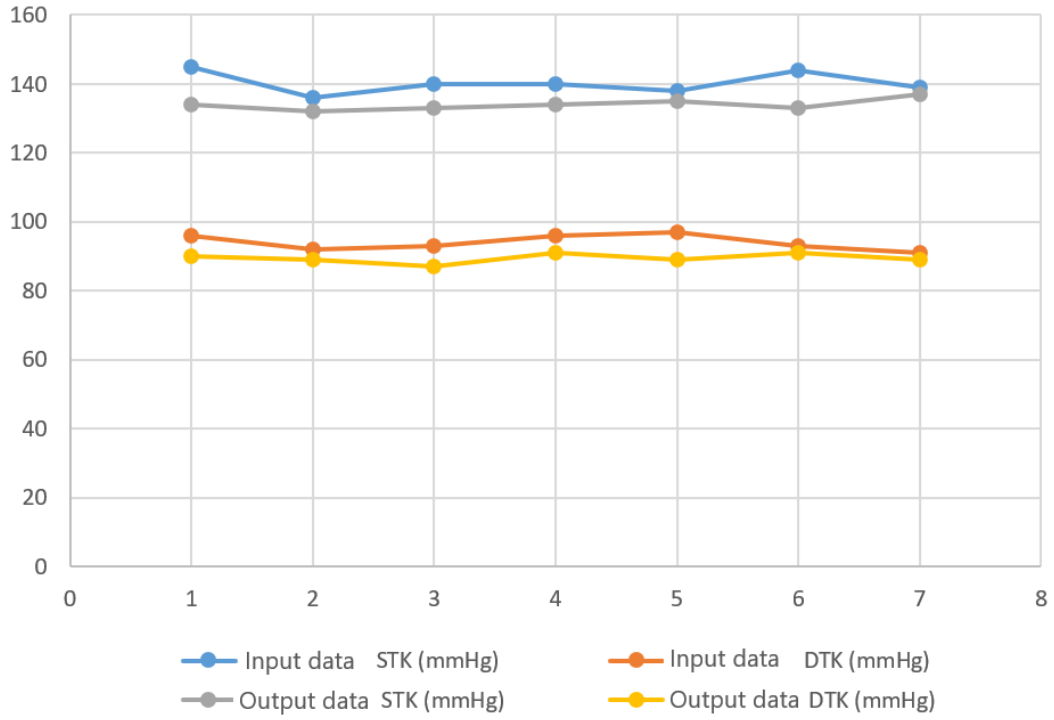


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Table 2: Morning systolic (SBP) and diastolic (DBP) blood pressure values

	Input measure		Output measure	
	SBP (mmHg)	DBP (mmHg)	SBP (mmHg)	DBP (mmHg)
1. day	145	96	134	90
2. day	136	92	132	89
3. day	140	93	133	87
4. day	140	96	134	91
5. day	138	97	135	89
6. day	144	93	133	91
7. day	139	91	137	89

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Table 3 compares the values of evening systolic and diastolic blood pressure measured before and after the end of the exercise intervention programme and these measurements are shown graphically in Figure 4.

Table 3: Evening systolic (SBP) and diastolic (DBP) blood pressure values

	Input measure		Output measure	
	SBP (mmHg)	DBP (mmHg)	SBP (mmHg)	DBP (mmHg)
1. day	133	88	127	85
2. day	133	91	130	88
3. day	137	92	135	87
4. day	128	89	125	86
5. day	132	88	123	86
6. day	130	89	120	84
7. day	131	90	130	89

source: own

Figure 4: Comparison of evening systolic and diastolic blood pressure

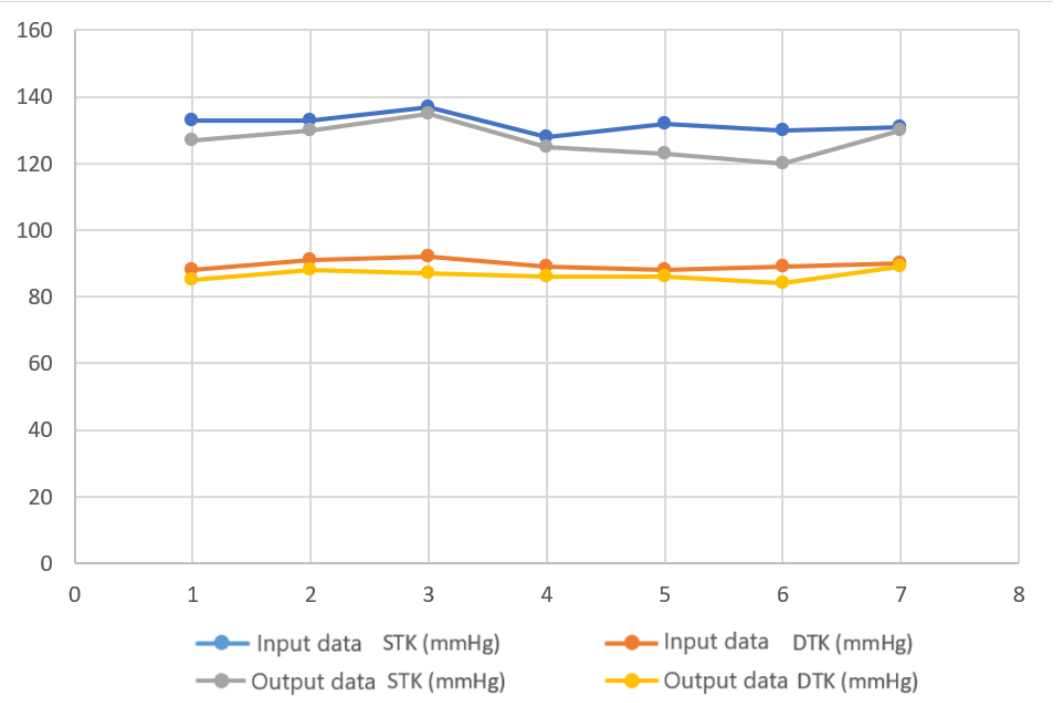

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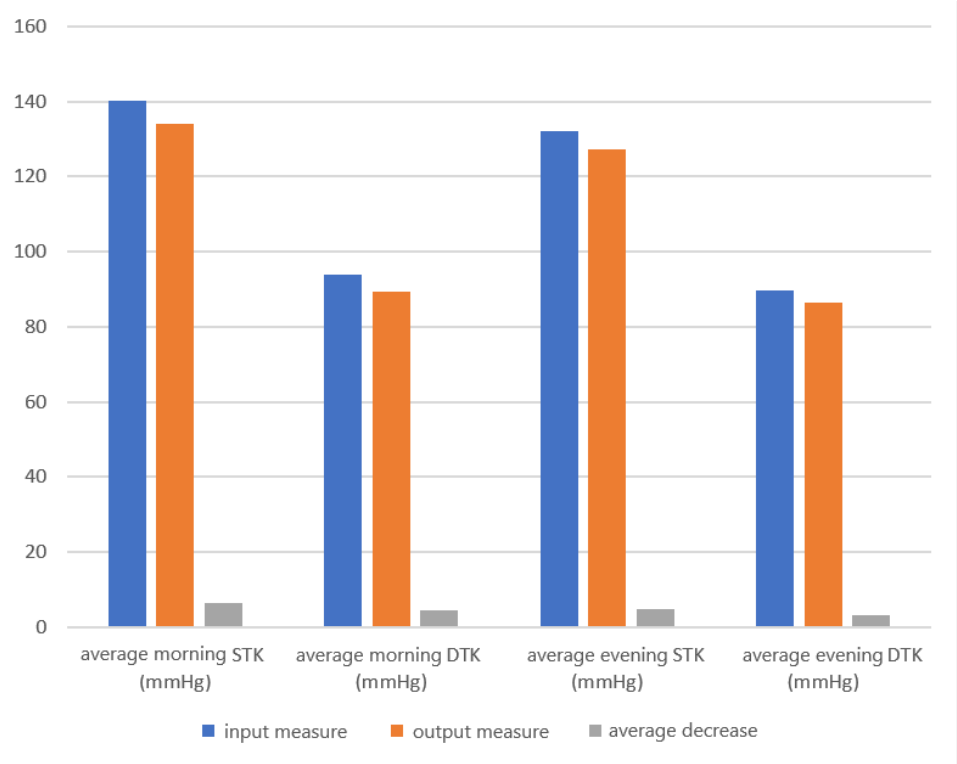
Table 4 records the average of the input and output blood pressure measurements and these measurements are compared graphically in Figure 5.

Table 4: Resulting blood pressure reduction

	Input measure	Output measure	Average decrease
average morning SBP (mmHg)	140,29	134,00	6,29
average morning DBP (mmHg)	94,00	89,43	4,57
average evening SBP (mmHg)	132,00	127,14	4,86
average evening DBP (mmHg)	89,57	86,43	3,14

source: own

Figure 5: Comparison of blood pressure values before and after the intervention programme



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Heart rate (pulse, beats per minute) was also recorded during blood pressure measurement. Table 5 compares the average heart rate values from morning and evening measurements before and after the interventional exercise programme.

Table 5: Resulting heart rate reduction

	Input measure	Output measure	Average decrease
average morning heart rate/min	69,43	65,57	3,86
average evening heart rate/min	70,14	65,86	4,28
average heart rate/min	69,79	65,72	4,07

source: own

WHR index

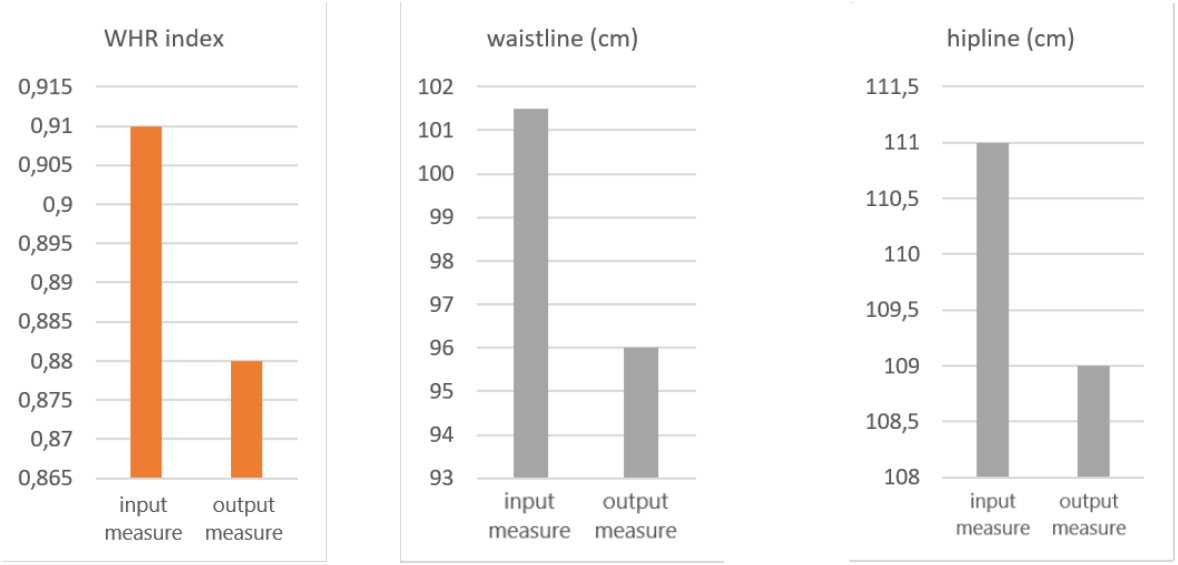
Table 6 compares the waistline, hipline and the WHR index calculated from them before and after the exercise intervention programme. These measurements are shown graphically in Figure 6. The waistline decreased by 5.5 cm, the hipline decreased by 2 cm and the WHR index value decreased and became closer to the cardiovascular disease risk threshold of 0.85 for women. However, this decrease in the WHR index was not yet sufficient to bring it below this threshold, so there is still a higher risk of cardiovascular disease.

Table 6: WHR index - comparison of results

	Input measure	Output measure
waistline (cm)	101,5	96,0
hipline (cm)	111,0	109,0
WHR index	0,91	0,88
assessing the level of risk	central risk	central risk

source: own

Figure 6: Resulting comparison of WHR index before and after the intervention programme



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Body weight, BMI and body fat percentage

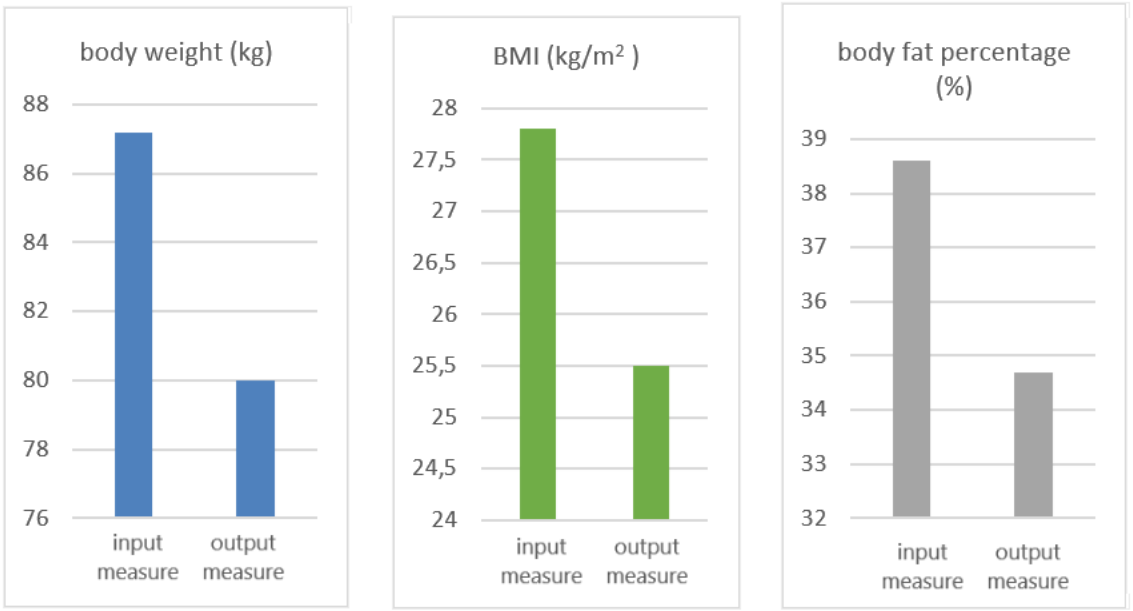
Table 7 compares body weight, BMI and body fat percentage before and after the exercise intervention programme. These measurements are shown graphically in Figure 7. Body weight decreased by 7.2 kg, BMI decreased to 25.5 kg/m2 and body fat percentage decreased by 3.9 %. Although BMI is still in the overweight range (25.0-29.9 kg/m2), it is much closer to the normal weight range (18.5-24.9 kg/m2).

Table 7: Body weight, BMI and body fat percentage - resulting differences

	input measure	output measure	resulting difference
body weight (kg)	87,2	80,0	-7,2 kg
BMI (kg/m2)	27,8	25,5	-2,3
body fat percentage (%)	38,6	34,7	-3,9 %

source: own

Figure 7: Body weight, BMI and body fat percentage - final comparison



Answer to the first research question:
The research in this paper confirmed the positive effect of regular walking on systolic blood pressure. Prior to the intervention programme, the average systolic blood pressure measured in the morning was 140.29 mmHg and in the evening was 132 mmHg. After the programme, the average systolic blood pressure measured in the morning hours dropped to 134 mmHg and in the evening hours to 127.14 mmHg. Thus, the study showed a decrease in systolic blood pressure when regular walking was included according to the conditions set by the intervention programme - the average reduction was 6.29 mmHg for morning values and 4.86 mmHg for evening values).

A study by Moreau et al. (2001), assessed the effect of walking on blood pressure values in postmenopausal women aged 53-55 years with high normal blood pressure or grade 1 hypertension, which corresponds to the selection of our proband, and the intervention programme lasted 12 weeks as in our study, systolic blood pressure values decreased by an average of 6 mmHg, with reductions occurring in both untreated women and women taking antihypertensives. Comparable reductions in values were achieved in our study.

Blumenthal et al. (2000), who in their study investigated the effect of aerobic physical activity combined with dietary modification aimed at weight loss, reported a decrease in systolic blood pressure of 7

mmHg. In our research, there was a reduction of 6.29 mmHg in morning values and 4.86 mmHg in evening values. We obtained a similar result for morning measurements, while the decrease was lower for evening measurements; however, it should be noted that the intervention programme in this study lasted twice as long (6 months) as in our research.

Lee et al. (2021) or Oja et al. (2018) reported in their meta-analyses a reduction in systolic blood pressure due to walking of 4 mmHg (more precisely, Lee and Oja by 4.11 and 4.05, respectively). In comparison, our proband had better results.

Fu et al. (2022) or de Barcelos et al (2022) in their meta-analyses reported a reduction in systolic blood pressure due to aerobic exercise by 10 mmHg (more precisely Fu by 9.91 and de Barcelos by 10.67 for training with progression and 10.17 for training without progression). Compared to the reductions in these two meta-analyses, our proband showed a lower reduction.

Answer to the second research question:

The research in this paper confirmed the positive effect of regular walking on diastolic blood pressure. Before the start of the exercise intervention programme, the average diastolic blood pressure measured in the morning was 94 mmHg and in the evening 89.57 mmHg. After the exercise intervention programme, the average diastolic blood pressure measured in the morning hours decreased to 89.43 mmHg and in the evening hours to 86.43 mmHg. Thus, the study showed a reduction in diastolic blood pressure when regular walking was included according to the conditions set by the exercise intervention programme - the average reduction was 4.57 mmHg for morning values and 3.14 mmHg for evening values.

In the study by Moreau et al. (2001), which assessed the effect of walking on blood pressure values in postmenopausal women aged 53-55 years with high normal blood pressure or grade 1 hypertension, which corresponds to the selection of our proband, and the intervention program lasted 12 weeks as in our study, no significant decrease was observed in diastolic blood pressure values. In contrast, in our study, there was a decrease in diastolic blood pressure, with a decrease of 4.57 mmHg for morning values and 3.14 mmHg for evening values.

Blumenthal et al. (2000), in their study investigating the effect of aerobic physical activity combined with dietary modification aimed at weight loss, reported a 5 mmHg decrease in diastolic blood pressure. In our study, a similar result was obtained for the morning measurement, and the decrease was lower for the evening measurement; however, it should be noted that the intervention programme in this study lasted twice as long (6 months) as in our research.

Lee et al. (2021) or Oja et al. (2018) reported in their meta-analyses a decrease in diastolic blood pressure due to walking of 1.8 mmHg (more precisely, Lee and Oja by 1.79 and 1.76, respectively). In comparison, our proband achieved better results.

Fu et al. (2022) in their meta-analysis reported a decrease in diastolic blood pressure due to aerobic physical activity by 4.32 mmHg. Comparable results to this reduction were achieved in our study.

De Barcelos et al. (2022) in their meta-analysis report a decrease in diastolic blood pressure due to aerobic exercise activity of 6 mmHg (more precisely, 5.49 for training with progression and 6.51 for training without progression). Compared to this result, the decrease in values was lower in our research.

It is also worth mentioning that in addition to the decrease in systolic and diastolic blood pressure, the proband also experienced a reduction in heart rate after completing the intervention programme. Lee et al. (2021) in their large meta-analysis evaluated the effect of walking on blood pressure in addition to its effect on heart rate, and the latter decreased by an average of 2.76 beats per minute in the results. Compared to this result, the decrease in our research was greater, with an average of 4.07 beats per minute.

Answer to the third research question: In addition to physical activity and adherence to nutritional measures, basic regimen measures in hypertension include weight reduction in overweight and obesity, which is logically closely related to the previous two measures. Abdominal (central) obesity, in which adipose tissue is deposited viscerally, is particularly risky.

The research in this paper confirmed the positive effect of recommendations for hypertension, such as the inclusion of regular physical activity and dietary modification, on reducing overweight and body composition. Prior to the intervention programme, the proband's body weight was in the overweight category and regular physical activity along with dietary modification resulted in weight reduction, reduction in body fat percentage and reduction in WHR index.

The proband's body weight decreased by 7.2 kg after the intervention programme (from 87.2 to 80 kg) and her BMI decreased from 27.8 to 25.5 kg/m2, her body fat percentage decreased by 3.9% (from 38.6 to 34.7%) and her WHR index decreased from 0.91 to 0.88 - see Tables 1 and 2. Although the BMI remained in the overweight range (25.0-29.9 kg/m2), it was much closer to the normal weight range (18.5-24.9 kg/m2). The decrease in WHR index was not sufficient to overcome the threshold for cardiovascular disease risk of 0.85 in women but nevertheless approached this threshold.
A study by Blumenthal et al. (2000), evaluated the effect of aerobic physical activity and dietary modification on blood pressure in addition to the effect on body weight and body composition (in a group of 55 sedentary overweight men and women over a 6-month period). Participants showed an average weight loss of 7.8 kg, a decrease in BMI of 2.7 kg/m2 and a reduction in body fat percentage of 3.2%. In our research, similar results were achieved in half the duration of the intervention programme.

CONCLUSION

The aim of this study was to test the effect of an exercise programme using walking and dietary modification on hypertension. The findings in this case study confirmed that moderate-intensity walking performed beyond normal daily activities, 5 times per week, for 12 weeks, with a progression of duration from 30 to 60 minutes per day, supported by dietary modification, leads to lower blood pressure in hypertensive patients and also has an effect on other risk factors for cardiovascular disease (overweight, body fat, central obesity). These findings are consistent with the literature on the effect of aerobic physical activity and diet on blood pressure and other risk factors for cardiovascular disease in patients with hypertension.

During the intervention programme, the proband showed a high rate of adherence to the recommended measures, which is essential for her future, as regimen measures in hypertension bring long-term positive results only if they are followed consistently. The proband felt very good about the results achieved and her attitude towards physical activity improved significantly. She continues to be motivated in this respect so that walking beyond the usual part of her daily

routine is likely to remain. The proband has also welcomed the modification of her nutritional regime; she has become accustomed to the changes and is likely to continue to follow the recommended nutritional measures in this area. With exercise and diet, she can keep her blood pressure within normal limits, and her weight can be reduced to normal - her motivation to do so was more than evident even after the intervention programme.

Hypertension is now a major problem worldwide. It is linked to lifestyles that are generally unhealthy in today's world. Therefore, the role of physicians and other professionals, including wellness specialists, is important to motivate patients to change their lifestyles. Walking as an aerobic physical activity is a good choice for the prevention, control and treatment of high blood pressure as it is affordable, safe and ultimately reduces the cost of pharmacological treatment.

REFERENCES

Blumethal, J. A., Sherwood, A., Gullette, E. C. D. et al. (2000). Exercise and Weight Loss Reduce Blood Pressure in Men and Women With Mild Hypertension. *Archives of Internal Medicine*. 160(13), 1947-1958. https://doi.org/10.1001/archinte.160.13.1947

Cífková, R. a kol. (2005). Společné doporučení českých odborných společností. Prevence kardiovaskulárních onemocnění v dospělém věku. *Klinická biochemie a metabolismus*. 13(4), 212-224.

Cífková, R. (2018). Nová doporučení pro diagnostiku a léčbu hypertenze. *Kapitoly z kardiologie pro praktické lékaře*. 10(2).

de Barcelos, G. T., Heberle, I., Coneglian J. C., Vieira, B. A., Delevatti, R. S., & Gerage, A. M. (2022). Effects of Aerobic Training Progression on Blood Pressure in Individuals With Hypertension: A Systematic Review With Meta-Analysis and Meta-Regression. *Front. Sports Act. Living.* 4:719063. https://doi.org/10.3389/fspor.2022.719063.

Fu, Y., Feng, Q., Wei, Y., Fan, L., Pan, Y., Ji, J., Lin, Ch., & Lou, X. (2022). Meta-Analysis of the Effect of Aerobic Training on Blood Pressure in Hypertensive Patients. *Computational and Mathematical Methods in Medicine*. Special Issue. https://doi.org/10.1155/2022/9281661

Hošková, B. a kol. (2012). *Vademecum: zdravotní tělesná výchova (druhy oslabení).* Karolinum.

Komárek, L. a kol. (2007, 18. prosince). Antropometrická vyšetření. http://www.szu.cz/tema/podpora-zdravi/antropometricka-vysetreni.

Koudelka, M. & Sovová, E. (2018). Hypertenze není jen nemoc s nutností léků. *Kardiologická revue – Interní medicína*. 20(4), 294-299.

Kužela, L. & Patlejchová, E. (2003). *Dieta při hypertenzi*. Triton.

Lee, L. L., Mulvaney, C., A., Wong, Y. K. Y., Chan, E. S., Watson, M. S., & Lin, H. H. (2021). Walking for hypertension. *Cochrane Database of Systematic Reviews*. 2. https://doi.org/10.1002/14651858.CD008823.pub2

Mikeš, O. & Tuka, V. (2020). Vliv pohybové aktivity na snížení hodnot krevního tlaku u pacientů s arteriální hypertenzí. *Kardiologická revue – Interní medicína*. 22(1), 13-16.

Moreau, K. L., Degarmo, R., Langley, J., McMahon, C., Howley, E. T., Bassett,

D. R. & Thompson, D. L. (2001). Increasing daily walking lowers blood pressure in postmenopausal women. *Medicine and Science in Sports and Exercise*. 33(11), 1825-1831. https://doi.org/10.1097/00005768-200111000-00005.

Novák, V. & Plačková, M. (2012). Spánek a hypertenze. *Medicína pro praxi*. 9(5), 242-245.

Oka, P., Kelly, P., Murtagh, E. M., Murphy, M. H., Foster, Ch. & a Titze, S. (2018). Effects of frequency, intensity, duration and volume of walking interventions on CVD risk factors: a systematic review and meta-regression analysis of randomised controlled trials among inactive healthy adults. *British Journal of Sports Medicine*. 52(12), 769-775. https://doi.org/10.1136/bjsports-2017-098558.

Physical Activity Guidelines Advisory Committee (2008). Physical Activity Guidelines Advisory Committee Report. Department of Health and Human Services, p. 683.

Pištorová, M. (2021). Zpráva o zdraví a nemocech. *Statistika&my – Magazín Českého statistického úřadu*. 11(7-8), 24-25. https://www.statistikaamy.cz/2021/08/18/zprava-o-zdravi-a-nemocech.

Psalmanová, D. a kol. (2017). *Výzkum ve sportovní medicíně II*. Masarykova Universita v Brně. Dostupné z: https://emuni.publi.cz/book/73-vyzkum-ve-sportovni-medicine-ii

Seliger, V. (1974). *Praktika z fyziologie pro studující tělesné výchovy*. Státní pedagogické nakladatelství.

Sovová, E. (2008). *Hypertenze pro praxi: pro lékaře, studenty, sestry, pacienty*. Univerzita Palackého v Olomouci.

Suchánek, P. (2013). Výživa – prevence kardiovaskulárních onemocnění. In L. Středa (ed.) *Obézní pacient v interdisciplinárním pohledu*. (str. 40-52). České vysoké učení technické v Praze.

Štejfa, M. a kol. (2007). *Kardiologie*. Grada.

Visseren, F. L. J, Mach, F., Smudlers Y. M. a kol. (2021). 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *European Heart Journal*. 42(34), 3227-3337. https://doi.org/10.1093/eurheartj/ehab484.

Vrablík, M., Cífková, R., Tuka, V. & Linhart, A. (2022). Doporučený postup Evropské kardiologické společnosti pro prevenci kardiovaskulárních onemocnění v klinické praxi 2021. Souhrn dokumentu připravený Českou kardiologickou společností. *Cor et Vasa*. 64(2), 165-211. doi: 10.33678/cor.2022.035.

Widimský, J. a kol. (2019). *Hypertenze*. Maxdorf.

Zaleski, A. (2019, 27. února). Exercise for the Prevention and Treatment of Hypertension – Implications and Application. https://www.acsm.org/blog-detail/acsm-certified-blog/2019/02/27/exercise-hypertension-prevention-treatment

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COMPENSATORY EXERCISES AS FLATFOOT PREVENTION IN TEAMGYM

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Abstract
The topic of this article is the issue of flat feet and the effect of compensatory exercises in TeamGym gymnasts. The aim of our study was to investigate and document the effect of specific compensatory exercises on the flatfoot condition in five selected gymnasts competing in TeamGym. The research questions were based on our practical observations and practice sessions with TeamGym gymnasts. Foot arch examination methods were used for the research part. Each athlete underwent initial testing, which included a standing examination, and each proband had her foot imprinted using Footdisc and Podoscope devices, all documented by taking photographs which were compared and evaluated before and after the intervention exercise. The results of the initial examination confirmed a flat foot and uneven foot loading in all gymnasts. Subsequently, interventional compensatory exercise was performed and lasted for three months. Output examination showed that after regular compensatory exercise, most probands showed some improvement in flat foot loading.

This work suggests that compensatory exercise should be incorporated into routine training to have a preventive effect on the undesirable development of flatfoot.

Keywords: *posture, compensation, plantar arch, flatfoot, degrees of flatfoot, TeamGym*

1. INTRODUCTION

TeamGym is a team sport that uses elements of gymnastics and acrobatics. It competes in three disciplines – a set for movement composition, acrobatics and jumping from a small trampoline. The large number of jumps and hard impacts that gymnasts perform barefoot is one of the reasons why, in our experience, flat-footedness problems are more prevalent in this sport. With the constant jumping, skipping and landing, the feet are subjected to excessive forces and the disparity between the load and the strength of the muscles and ligaments is one of the causes of flat feet in gymnasts. Changes caused by poor pressure distribution of the flat foot can create dysfunction of the foot and other upper body segments, but can also increase the risk of other serious lower extremity injuries. Targeted compensatory exercises to affect the flatfoot should be an important part of the training process in these types of gymnastic sports. TeamGym is a team sport that uses elements of gymnastics and acrobatics. It is competed in three events - tumbling routines, acrobatics and jumping from a small trampoline. The large number of jumps and hard impacts that gymnasts perform barefoot is one of the reasons why, in our experience, flat-footedness problems are more prevalent in this sport. With the constant jumping, skipping and landing, the feet are subjected to excessive forces and the disparity between the load and the strength of the muscles and ligaments is one of the causes of flat feet in gymnasts. Changes caused by poor pressure distribution of the flat foot can create dysfunction of the foot and other upper body segments, but can also increase the risk of other serious lower extremity injuries. Targeted compensatory exercises to affect the flatfoot should be an important part of the training process in these types of gymnastic sports.

2. AIM AND RESEARCH QUESTIONS

The aim of our study was to verify and document the effect of a specific compensatory exercise on plantarflexion in five female athletes competing in Teamgym. The research questions were based on our practical observations and practice sessions with the team gymnasts. We were interested in whether a flatfoot disorder would be found in all the gymnasts examined and whether there would be an improvement in the overall weight distribution on the gymnasts' feet after the three-month exercise program.

3. METHODOLOGY

Five young female gymnasts aged between 10 and 12 years old who have been involved in TeamGym for at least 6 years and train 4 times a week were selected for the study. The girls' parents agreed to participate in the research. Initial testing included standing and gait aspect testing, and each proband's feet were imprinted using Footdisc and Podoscope devices. The standing examination and foot impression on both devices were documented by taking photographs, which were compared and evaluated after three months. Based on the input examination, a compensatory exercise program was developed to improve plantar foot position. The exercise program was carried out over a period of three months. The probands exercised 4 to 5 times a week, for 15 minutes. In addition to continuous quality control of exercise execution during the training, the gymnasts had a recorded video with individual exercises and detailed descriptions and could also consult their possible problems regarding the exercises with the supervising coach - co-author of the paper.

The output examination again included a standing examination, and a foot examination on the Podoscope and Footdisc devices, along with photo documentation for final comparison of results. Compensatory exercises included five exercises to activate the longitudinal and transverse arches along with stimulation of the small muscles of the foot. All exercises were performed barefoot, on a hard mat, and, when possible, in front of a mirror. The selected exercises are shown in Figures 1-5 (stimulation of the plantar surface of the foot using a rehabilitation hedgehog, training of the four-point foot support, activation of the transverse arch of the foot, training of the 'small foot' and toe abduction).

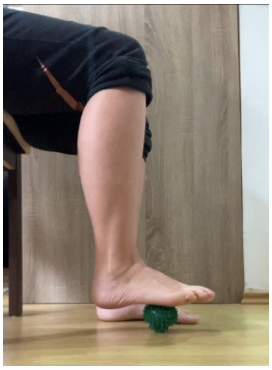

Fig. 1: Stimulation of the foot muscles (source: autors)

Fig. 2: Training the four-point foot support (source: autors)

Fig. 3: Activation of the transverse arch of the foot (source: autors)

Fig 4: Abduction training of the big toe
(source: autors)

Fig. 5: Small foot training
(source: autors)

4 RESULTS AND DISCUSSION

The results of the examination of individual probands were processed in the form of case reports. Here we present the photo documentation of the examination of the foot loading of each proband before and after the exercise program and our overall evaluation of each proband separately.

Proband no. 1.
The initial examination of proband No. 1 is shown in Figures 6-8. It can be noted that there is no loading of the pinkie on the right foot and a slight reduction of the longitudinal arch on the left is visible. According to the Footdisk scale, the proband is in category C and according to our visual scaling, she is a first-degree flatfoot. This is the principle of the visual scaling method (Kapanji, 1987), which consists of comparing the shape of the plantogram of the healthy foot with the examined one (Riegerová, Přidalová, Ulbrichová, 2006).

Proband no. 1 before intervention

Fig. 6: foot position (source: authors)

Obr. 7: load on Podoscope (source: autors)

Fig. 8: load on Footdisc (source: authors)

After the exercise, the proband's pinkies loading improved, the foot arches flattened and there was a change in the Footdisc rating scale to grade B, and according to visual scaling, we determined that this was a normal foot (Figures 9-11).

Proband no. 1 – after three month of intervention

Fig. 9: foot position (source: authors)

Fig. 10: load on Podoscope (source: authors)

Fig. 11: load on Footdisc (source: authors)

Proband no. 2 The initial examination of proband No. 2 is shown in Figures 12-14. We can note that there is a visible bilaterally reduced internal longitudinal arch of the foot more visible on the right and the right little toe is unloaded. According to the Footdisc rating scale, the proband is in category D and according to our visual scaling, this is a grade two flatfoot.

Proband no. 2 before intervention

Fig. 12: foot position (source: authors)

Fig. 13: load on Podoscope (source: authors)

Fig. 14: load on Footdisc (source: authors)

Proband no. 2 – after three months of intervention

Fig. 15: foot position (source: authors)

Fig. 16: load on Podoscope (source: authors)

Fig. 17: load on Footdisc (source: authors))

After the exercise, the proband reported improvement on the left foot but had difficulty with the exercise on the right foot. This was evident on the exit examination, particularly on the footprint on the device, where the left foot improved by one degree of flatfoot according to visual scaling. We rate the visual scaling as grade I on the left and grade II on the right for flatfoot. Bilaterally, there is a small heel load and decreased internal longitudinal arch of the foot on the right, the left big toe along with the 1st metatarsal is almost unloaded along with a small load of the 2nd -5th toe on the right. The Footdisc flatfoot rating improved to a C rating on the right and a B rating on the left (Figures 15-17).

Proband no. 3.

The initial examination of proband no. 3 is shown in Figures 18-20. On the Podoscope, more load is visible on the inner edges of both feet. Examination on Footdisc shows decreased loading of the left toes, also bilaterally decreased inner longitudinal arch of the foot more to the right. Thus, according to our assessment, this is a Footdisc C flatfoot and we rate it a grade I flatfoot according to visual scaling.

Proband no. 3 – before intervention

Fig. 18: foot position (source: authors)

Fig. 19: load on Podoscope (source: authors)

Fig. 20: load on Footdisc (source: authors)

Proband no. 3 – after three months of intervention

Fig. 21: foot position (source: author)

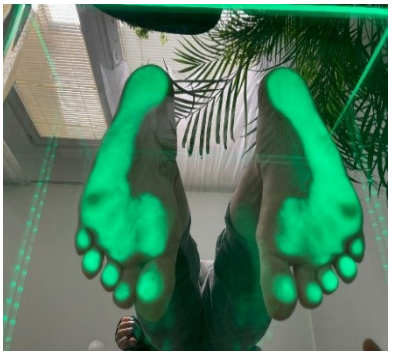

Fig. 22: load on Podoscope (source: authors)

Fig. 23: load on Footdisc (source: authors)

After the three-month intervention, the proband reports that she subjectively perceives an overall improvement in the position of her feet and ankle joints. Exit examination using Footdisc assesses a slight reduction of the internal longitudinal arch bilaterally, the weight of the body is reflected more on the right foot and bilateral loading of all toes is visible. We assess the Footdisc grades by visual scaling, assessing as a normal foot. On examination with the Podoscope, we observe V. metatarsal unloading bilaterally with decreased left toe loading (Figures 21 - 23).

Proband no. 4.

The initial examination of proband no. 4 is shown in Figures 24 - 26. On examination of the posterior aspects, there is a visible loading of the feet on the medial edges with slight internal impingement of the hindfoot, a reduced internal longitudinal arch of the foot with a valgus position of the heels is visible, and the Achilles tendons are asymmetrical. Podoscope examination shows bilateral loading of the inner edges of the feet, more on the left. Thus, we rate the visual scaling as grade II flatfoot. Footdisc examination shows the 2nd and 3rd toes of the right foot unloaded with bilateral reduction of the left inner longitudinal arch of the foot. The Footdisc flatfoot rating is C.

Proband no. 4 – before intervention

Fig. 24: foot position (source: author)

Fig. 25: load on Podoscope (source: authors)

Fig. 26: load on Footdisc (source: authors)

Proband no. 4 – after three months of intervention

Fig. 27: foot position (source: authors)

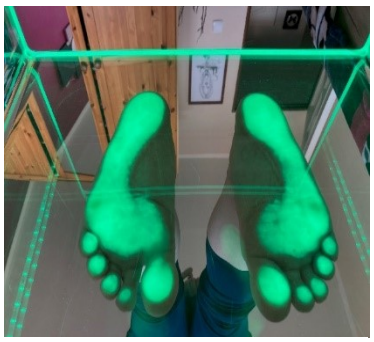

Fig. 28: load on Podoscope (source: authors)

Fig. 29: load on Footdisc (source: authors)

After the interventional exercise, the valgus position of the ankle joints and bilaterally reduced internal longitudinal arch of the foot are still evident. A slight valgus position of the calcaneus is still evident with the reduced internal longitudinal arch of the foot bilaterally, with Achilles tendons pointing obliquely medially bilaterally. The load on the whole body is more on the heels. The Podoscope exit examination shows a small load on the second toe of the right foot. Visual scaling assessment is left I. grade flatfoot and right grade II flatfoot. Output examination by Footdisc assesses a slightly reduced internal longitudinal foot arch bilaterally but more so on the right. The Footdisc flatfoot rating is a left rating of B and the right rating of C. The proband evaluates the entire therapy positively, mostly for the foot pain she experienced frequently prior to therapy after any major exertion. These pains have completely resolved (Figures 27-29).

Proband no. 5

The initial examination of proband no. 5 is shown in Figures 30 - 33. Examination of the feet by inspection reveals a valgus position of the calcaneal bones bilaterally, asymmetry of the Achilles tendons, which point obliquely medially, more to the left, as well as a narrow base width and longitudinal reduction of both feet. From the Podoscope examination, we evaluate less loading of the left little toe compared to the right one and a slight lightening of both V. metatarsals. The visual scaling assessment corresponds to a I. grade flatfoot. The Footdisc examination shows a greater load on the right LL with a more pronounced loading of the inner edge of the foot on the left. Footdisc flatfoot rating C.

Proband no. 5 –before intervention

Fig. 30: foot position (source: authors)

Fig. 31: load on Podoscope (source: authors)

Fig. 32: load on Footdisc (source: authors)

Proband no. 5 – after three months of intervention

Fig. 33: foot position (source: author)

Fig. 34: load on Podoscope (source: authors)

Fig. 35: load on Footdisc (source: authors)

After a three-month intervention, the proband felt progress on her left foot, which was also better exercised. There was no visible progress in terms of the instrumented examination compared to the initial examination. There is still bilateral unloaded body weight distribution to the foot and 4th and 5th toes of the left foot, and bilateral reduction of the internal longitudinal plantar arch persists. Exit examination using Podoscope assesses the left little toe still in reduced load and bilateral minor V metatarsal loading. We diagnose the assessment by visual scaling as I. grade flatfoot. According to Footdisc, we grade the flatfoot as grade C (Figures 33-35).

4 DISCUSSION

Pes planovalgus meaning pediatric flatfoot, is one of the most common orthopaedic defects in children, occurring as they grow. López (2014) reports that up to 30% of all children suffer from foot arch disorders. Dungl (2005) describes typical signs indicative of flatfoot problems as the tibia dropping medially and walking with the toes turned inward. In contrast, a study by Vergillos, et al. (2023) mentions that flatfoot is a common finding in children under 10 years of age and is somewhat normal during development. Therefore, pediatric flatfoot should not be considered pathological unless stiffness or functional limitation is present.

Our initial examination revealed a problem with flatfoot in all the gymnasts tested, to varying degrees. All girls were also found to have valgus of the calcaneus, Achilles tendon pointing medially bilaterally, and drop of the tibia medially. Toe-in gait was not seen in any of the girls. On the contrary, one of the gymnasts showed the opposite feature manifested by standing and walking with the toes outwards, which, in our opinion, may lead to additional unwanted loading in running or in jumping from challenging elements, which may subsequently negatively affect the upper body segments.

The postural function of the foot is also a source of proprioceptive and exteroceptive information for the central nervous system (Vařeka, 2009). It follows that pathological foot position or impaired foot function is associated with impaired motor stereotype. This in turn can affect the posture and function of the entire lower limbs and the whole body's axial system (Toppischová and Šnoplová, 2008). Using various physiotherapeutic techniques and targeted compensatory exercises for the plantar foot, it is then possible to influence the associated problems associated with faulty posture. (Buchtelová and Vaníková, 2010).

Since we had the opportunity to observe the gymnasts during the training program, we can state that even there, the consequences of incorrect loading of the plantar foot are evident in individual elements (e.g., one-legged stand on the balance beam or precision push-ups).

It is clear that after three months of regular compensatory exercises, there was some improvement in the loading of the footplate in most of the probands, so it is certainly appropriate to recommend adding compensatory exercises focusing on the correct function of the footplate to the training plan of gymnasts.

One of the basic compensatory exercises that has been applied to gymnasts is the "four-point foot support" exercise, which is the essence of full body support. Dylevský (2009), describes that the foot has three points for proper and even loading, Kapandji (1987) advocates four-point support. As demonstrated in our study, targeted exercise and stimulation of the plantar surface of the foot can lead to improved use of this four-point support; most gymnasts were able to distribute their body weight evenly over the entire foot,

and one gymnast achieved conscious loading of her little toes to the ground, something she was unable to do prior to therapy.

This included a final interview to subjectively assess the effect of the three-month therapy. Three of the tested gymnasts reported that the compensatory exercises helped to relieve their leg pain, while others became more aware of the alignment of their entire lower limb. All probands were aware of the possible consequences of poor loading of the plantar surface of the foot after the programme. A study by Knappová, Charvátová and Stackeová (2022) showed that the effects of a movement intervention and regimen can be corrected without the need for orthotic insoles or other special footwear modifications. If exercise is not regularly performed and regimen measures are not followed, the effect of the intervention diminishes. Other influences, such as inappropriate sporting activity or inappropriate footwear, may also negate the positive effect of the intervention.

5 CONCLUSIONS

The issue of flat feet in gymnasts competing in TeamGym is often a neglected topic. However, due to the demanding nature of the sport and the heavy load placed on the lower limbs, it is a topic of utmost importance, especially in the prevention of injury and the development of any chronic pain conditions occurring in the sport. Compensatory exercises targeting the plantar region of the foot, according to our observation, appear to be a suitable tool for maintaining the functionality not only of the lower limbs but of the entire musculoskeletal system.

REFERENCES

Adamec, O. (2005). Plochá noha v dětském věku – diagnostika a terapie. *Pediatrie pro praxi*, 4, 194-196.

Buchtelová, E., & Vaníková, K. (2010). Rehabilitace v oblasti chodidla u dětí školního věku. *Reh*, 47(3), 145-152.

Dungl, P. (2005). *Ortopedie*. Grada.

Dylevský, I. (2009). *Funkční anatomie*. Grada.

López López, D., Bouza Prego, M., Requeijo Constenla, A., Saleta Canosa, J. L., Casasnovas, A. B., & Tajes, F. A. (2014). The impact of foot arch height on quality of life in 6-12 year olds. *Colombia Médica*, 45(4), 168-172.

Kapandji, I. A. (1987). *The Physiology of the Joints*, Churchill-Livingstone. New York, 76-103.

Knappová, V., Charvátová, A., & Stackeová, D. (2022). Correction of defective foot position in a preschool child-case report. *Acta Salus Vitae*, 10(2), 15-24.

Riegerová, J., Přidalová, M., & Ulbrichová, M. (2006). *Aplikace fyzické antropologie v tělesné výchově a sportu (příručka funkční antropologie)*. Hanex.

Vergillos Luna, M., Khal, A. A., Milliken, K. A., Solla, F., & Rampal, V. (2023). Pediatric Flatfoot: Is There a Need for Surgical Referral?. Journal of Clinical Medicine, 12(11), 3809.

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