THE EFFECT OF VARIOUS TRAINING REGIMENS ON PERFORMANCE, BODY MASS INDEX, STRENGTH, FLEXIBILITY AND ENDURANCE IN MIDDLE-AGED WOMEN: A RANDOMIZED CONTROLLED TRIAL

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doi: 10.32626/2309-8082.2024-29(4).175-181

In this study, the influence of identical training sessions conducted at different times of the day on the indicators of physical performance, body mass index, strength, flexibility and endurance of women aged 45-50 years was studied. It was assumed that conducting training sessions in the morning from 9 to 10 o'clock and in the evening from 18 to 19 o'clock may have a different effect on health indicators in middle-aged women engaged in fitness. *The purpose of the study is* to improve the methods of recreational physical exercises with middle-aged women. *Research objectives:* analysis of current research in the field of methods of conducting recreational physical exercises with middle-aged women; development of a fitness program for women 45-50 years old; assessment of the impact of fitness classes at different times of the day on performance indicators, body mass index, strength, flexibility and endurance in women 45-50 years old. *Conclusions*: in the training process of middle-aged women, it is necessary to take into account the time of classes and make a decision on the dosage of special exercises or change the schedule of training sessions; training sessions of a complex nature for women 45-50 years old, performed in the morning (from 8 to 9 o'clock), can be effective to increase physical performance and reduce body weight; training sessions performed in the evening (from 18 to 19 hours) can be effective for developing strength and reducing body weight.

Keywords: women, fitness, training regime, strength, endurance, flexibility, physical performance, body mass index.

Ольга Самолюк, Тетяна Чебан, Анастасія Шишкану. **Вплив різних режимів тренувальних занять на показники працездатності, індексу маси тіла, сили, гнучкості та витривалості у жінок середнього віку: рандомізоване контрольоване дослідження**

Анотація. В даному дослідженні було вивчено вплив однакових за змістом тренувальних занять, що проводяться в різний час доби, на показники фізичної працездатності, індексу маси тіла, сили, гнучкості і витривалості жінок 45-50 років. Передбачалося, що проведення тренувальних занять вранці з 9 до 10 годин і ввечері з 18 до 19 годин може мати різний ефект на показники здоров›я у жінок середнього віку, що займаються фітнесом. *Мета дослідження* – вдосконалення методики оздоровчих занять фізичними вправами з жінками середнього віку. *Завдання дослідження*: аналіз актуальних досліджень в області методики проведення оздоровчих занять фізичними вправами з жінками середнього віку; розробка програми занять фітнесом для жінок 45-50 років; оцінка впливу занять фітнесом в різний час доби на показники працездатності, індексу маси тіла, сили, гнучкості і витривалості у жінок 45-50 років. *Висновки*: у тренувальному процесі жінок середнього віку необхідно враховувати час проведення занять і приймати рішення щодо дозування спеціальних вправ або ж змінювати розклад тренувальних занять; тренувальні заняття комплексного характеру для жінок 45-50 років, що виконуються в ранкові години (з 8 до 9 годин), можуть бути ефективними для підвищення фізичної працездатності і зниження маси тіла; тренувальні заняття, що виконуються у вечірні години (з 18 до 19 годин), можуть бути ефективними для розвитку сили і зменшення маси тіла.

Ключові слова: жінки, фітнес, режим тренувань, сила, витривалість, гнучкість, фізична працездатність, індекс маси тіла.

Introduction

Physical activity is a known risk factor for human health. Even a slight decrease in physical activity can significantly increase the risk of diseases. The situation with obesity and dysmetabolism continues to worsen worldwide [3]. One third of adults in the world do not achieve the required level of physical activity, which includes recommendations for the quality and quantity of physical exercise. Middle-aged women are no exception [17]. Recommendations for public health are mainly aimed at the need for regular exercise as a prevention of cardiovascular diseases, type 2 diabetes and age-related muscle atrophy [18; 22]. Studies show that the lack of results from regular physical exercise in the form of weight loss, improved appearance and other effects can significantly reduce motivation to continue the process of physical improvement [4].

The average age of 45-50 years is a period of life when there is a tendency to decrease the percentage of muscle mass, control over body fat decreases as a result of the peculiarities of the production of a number of hormones [1; 15; 16]. Middle-aged women in most countries of the world prefer to exercise regularly to improve their well-being and appearance. In training sessions aimed at developing strength, flexibility, endurance and weight loss, a wide range of exercises is usually used. Strength training and functional training come out on top, suggesting an integrated approach to the development of muscle groups and physical qualities [6; 7; 9; 19]. The effectiveness of training can depend on many factors. One of these factors is the training regime. Classes held at different times of the day (morning, afternoon or evening) can have different effects. Achieving goals such as weight loss, improving physical performance, developing strength, flexibility and

endurance largely depends on physical and psychological readiness to perform physical exercises, as well as on the characteristics of recovery processes after physical exertion [23].

For example, some women prefer to exercise in the morning. In the morning, there is a peak in growth hormone levels in the blood, which creates favorable conditions for reducing subcutaneous fat. The effect is also achieved by reducing appetite in the hours following physical exertion and increasing metabolism within 12 hours after a training session. However, the level of the hormone cortisol in the morning reaches its highest levels, which negatively affects the processes of building muscle mass [4]. Nevertheless, most women prefer to train in the evening, which is associated with the working day. In the evening, the level of the hormone testosterone tends to the highest levels, which can have a beneficial effect on increasing muscle mass. In turn, the level of the hormone cortisol, known as the stress hormone, is lower in the evening than in the morning. From this point of view, evening workouts are most beneficial for gaining muscle mass, and morning workouts are most beneficial for weight loss [11; 12]. Thus, there is a contradiction between the need to obtain various health-improving effects from training sessions, but a low probability of realizing two important tasks from morning or evening training: reducing the percentage of subcutaneous fat and increasing muscle mass. Nevertheless, the health-improving effect of physical activity can also be observed in terms of strength, flexibility, endurance and performance and achieved through a comprehensive training program.

The proposed empirical experience can be useful for those who plan and carry out training activities with middle-aged women at different times of the day and expect to improve physical performance, body mass index, strength, flexibility and endurance.

Materials and methods of research

The purpose of the study is to improve the methods of recreational physical exercises with middle–aged women. *Research objectives*: analysis of literature in the field of methods of conducting wellness training sessions with middle-aged women; development and implementation of a program of complex training sessions in the training process carried out at different times of the day; assessment of the impact of complex training sessions of the same content and duration, but conducted at different times of the day, on performance indicators, body mass index (BMI), strength, flexibility and endurance in women 45-50 years old. The hypothesis of the study: the wellness effect of regular training sessions in women 45-50 years old may be significant, but it may differ depending on the time of classes, which may become the basis for reviewing the program of classes held at different times of the day for better effectiveness.

Theoretical research methods: critical analysis and synthesis of data from relevant literary sources, comparison, deduction, induction. *Empirical research methods:* measurement of strength indicators (squatting with a barbell with a weight of 50% of the maximum, lifting straight legs in a hanging position on a crossbar to an angle of 900, pulling up on a low crossbar), flexibility (leaning forward from a sitting position, performance (Harvard step test), endurance (running 1000 m), body mass index (BMI). A pedagogical experiment was conducted (randomized controlled trial), mathematical methods of statistical data processing (Student's T coefficient) were used. The pedagogical experiment was organized with the participation of 22 women aged 45-50 years who regularly visit the fitness center for a year or more. All participants of the experiment were familiar with the conditions of the study, have access to physical exercises and have no medical contraindications. The personal data of the participants in the experiment were not disclosed.

Before the start of the pedagogical experiment, all participants visited the laboratory, where indicators of physical performance, body mass index, strength, endurance and flexibility were measured. The experimental group No. 1 included women who attend the gym in the morning (11 people). Group No. 2 included women who train in the evening (11 people). After the completion of the pedagogical experiment, all participants were tested again in the laboratory. The changes in indicators in each of the groups of subjects were compared and evaluated. The interest was aroused by which of the experimental groups would show the best changes in health and physical fitness after 9 months of regular training. The experiment lasted from January 2024 to October 2024. The experiment was conducted with the assistance of the Aerobics Federation in the city of Tiraspol (Republic of Moldova).

The results of the research

The main goals pursued by middle–aged women when visiting gyms are to reduce body fat, improve well-being and appearance. In general, such results may indeed indicate an improvement in health indicators. Research shows that in recent years, high-intensity interval training sessions have become of the highest interest, which, compared with traditional continuous exercises of lower intensity and the same volume, better solve the problem of weight loss and help reduce the amount of body fat [8; 10; 21]. For middle-aged people who want to improve their health through physical exercise, it is preferable to use complex training [28; 29; 30]. Such workouts are considered more energy-intensive, since a significant number of muscle groups are activated. When a large number of muscle groups are activated during exercise, the production of the

hormone testosterone is stimulated, which contributes to an increase in the volume of muscle fibers [13; 20].

In the process of strength training of a complex nature, the technique of basic physical exercises is better mastered: squats, presses, deadlifts and others. Proper performance of basic exercises leads to an increase in the quality of the training process and a subsequent increase in strength indicators [6; 7]. Techniques that involve a combination of strength training, cardio training and flexibility exercises for middle-aged women demonstrate the best effectiveness, since they increase the likelihood of increasing the functionality of body systems, developing strength and endurance, reducing body weight and improving body composition [24; 25; 26].

As mentioned above, the difference in hormonal status in the morning and evening hours is an important factor that changes the emphasis in the training process. In this regard, the experimental groups were engaged in the same training program, including cardio load at the beginning of the lesson, strength load in the middle of the lesson and exercises for mobility in joints and coordination load in the final part of the lesson. The duration of each training session is 60 minutes. Training sessions were held three times a week. Thus, in each lesson, cardio exercises were performed for 20 minutes, strength exercises with and without weights were performed for 30 minutes, joint mobility exercises in combination with coordination exercises – 10 minutes. The only difference between the two experimental groups was the time of the training sessions. Group No. 1 was engaged from 9 a.m. to 10 a.m., group No. 2 was engaged from 6 p.m. to 7 p.m.

Testing before the start of the pedagogical experiment showed that the level of development of strength, flexibility and endurance in both experimental groups is at or below the average level. The presented test results did not show significant differences between the averages (Table 1).

Table 1 – Indicators of strength, flexibility and endurance in women before the start of the experiment

Indicators	Experimental group № 1 (n=11)			Experimental group № 2 (n=11)			*t*	*p*
	$\bar{x}$	δ	*m*	$\bar{x}$	δ	*m*		
Running 1000 m (min)	7.50.0	1.10.0	0.35.0	8.00.5	1.20.0	0.30.0	0.6	>0.05
Forward tilt (cm)	6.8	1.5	0.5	6.9	1.3	0.4	0.8	>0.05
Barbell Squat (number of times)	8.8	2.2	0.7	9	2.1	0.7	0.7	>0.05
Lifting straight legs in the temple (number of times)	3.9	0.8	0.25	3.7	0.6	0.2	0.6	>0.05
Pull-up on a low crossbar (number of times)	5.0	0.7	0.2	5.7	0.8	0.25	0.6	>0.05

N o t e *The differences are significant at t = 1.7 (0.05), 2.08 (0.01); (df=20).

The results of testing the level of physical performance and body mass index, shown at the beginning of the pedagogical experiment, indicate an average level of physical fitness and the presence of overweight in most women in both groups. Passing the Harvard step test for healthy people (untrained group) – the results are below average (56-65 points). Body mass index (qualitative body composition of the Quetelet Index) – overweight (25-30 points). There were no significant differences between the observed groups in the average indicators (Table 2).

Table 2 – Indicators of physical performance and mass index the bodies of women before the start of the experiment

Indicators	Experimental group № 1 (n=11)		Experimental group № 2 (n=11)		U-criteria	p
	Average score	The sum of the ranks	Average score	The sum of the ranks		
The Harvard Step Test	65.1	140	63.2	113	47	> 0.05
BMI	27	120	26	133	54	> 0.05

N o t e *The differences are significant at U ≤ 34 (0.05), 25 (0.01)

Low indicators of strength, flexibility, and endurance in both groups of subjects indicate the need to take into account a number of factors, including the time of training sessions. After 9 months of regular classes, all the participants in the experiment were tested again. The change in indicators in each of the groups was of interest. Thus, the initial indicators in exercises and tests were compared with the results shown by the group at the end of the pedagogical experiment.

In experimental group No. 1, according to the results of the experiment, significant changes in endurance performance in the 100 m run ($p<0.05$) were recorded, however, the changes still do not significantly exceed the confidence threshold, they are in the zone of uncertainty, which may indicate the influence of some unknown and ignored factors. Mobility and strength tests also showed an improvement in indicators, but not exceeding the confidence threshold ($p>0.05$) (Table 3).

Table 3 – Changes in physical fitness indicators in Group No. 1 (n=11)

Indicators	Results before the experiment			Results after the experiment			*t*	*p*
	$\bar{x}$	δ	*m*	$\bar{x}$	δ	*m*		
Running 1000 m (min)	7.50.0	1.10.0	0.35.0	6.30.0	0.45.0	0.15.0	2.6	<0.05
Forward tilt (cm)	6.8	1.5	0.5	7.2	1.6	0.5	0.6	> 0.05
Barbell Squat (number of times)	8.8	2.2	0.7	9.1	2.4	0.8	0.8	> 0.05
Lifting straight legs in the temple (number of times)	3.9	0.8	0.25	4.2	0.9	0.3	0.8	> 0.05
Pull-up on a low crossbar (number of times)	5.0	0.7	0.2	5.9	0.6	0.2	0.9	> 0.05

N o t e *The differences are significant at t = 2.23 (0.05), 3.17 (0.01).

In experimental group No. 2, positive dynamics was found in all the presented exercise tests. The changes in strength indicators turned out to be statistically significant. The best indicators were recorded when demonstrating the relative strength of the muscles of the upper shoulder girdle and lower limb girdle (p<0.01). Changes in running endurance were also positive, however, not enough to establish reliability (p>0.05). The indicator of flexibility development remained at the level of uncertainty (<0.05) (Table 4).

Table 4 – Changes in physical fitness indicators in Group No. 2 (n=11)

Indicators	Results before the experiment			Results after the experiment			*t*	*p*
	$\bar{x}$	δ	*m*	$\bar{x}$	δ	*m*		
Running 1000 m (min)	8.00.5	1.20.0	0.30.0	7.45.0	0.40.5	0.12.0	0.5	>0.05
Forward tilt (cm)	6.9	1.3	0.4	8.0	1.45	0.5	2.9	<0.05
Barbell Squat (number of times)	9	2.1	0.7	12	2.5	0.8	3.1	<0.05
Lifting straight legs in the temple (number of times)	3.7	0.6	0.2	5.2	0.6	0.2	3.7	<0.01
Pull-up on a low crossbar (number of times)	5.7	0.8	0.25	7.5	0.5	0.16	3.9	<0.01

N o t e *The differences are significant at t = 2.23 (0.05), 3.17 (0.01).

In experimental group No. 1, positive significant changes in physical performance indicators (< 0.01) and body mass index indicators (< 0.01) were also noted. Thus, body mass index indicators in the group reached the norm. Physical performance indicators have increased and reached an average level for this category of people (Table 5).

Table 5 – Changes in physical performance indicators and body mass index in group No. 1 (n=11)

Indicators	Results before the experiment		Results after the experiment		U-criteria	p
	Average score	The sum of the ranks	Average score	The sum of the ranks		
The Harvard Step Test	65.1	78	68.5	175	12	< 0.01
BMI	27.5	177	25.2	76	10	< 0.01

N o t e *The differences are significant at U ≤ 34 (0.05), 25 (0.01)

In experimental group No. 2, the final indicators of physical performance also improved at the end of the experiment, however, they remained at the level of uncertainty (< 0.05). The average body mass index reached normal values, which was also reflected in the reliability of the differences between the initial data and the data at the end of the experiment (< 0.01) (Table 6).

Table 6 – Changes in physical performance indicators and body mass index in group No. 2 (n=11)

Indicators	Results before the experiment		Results after the experiment		U-criteria	p
	Average score	The sum of the ranks	Average score	The sum of the ranks		
The Harvard Step Test	63.2	93.5	64.4	179.5	27.5	< 0.05
BMI	26.3	178.5	25	74.5	8.5	< 0.01

N o t e *The differences are significant at U ≤ 34 (0.05), 25 (0.01)

Discussion

A scientific approach to the organization and content of wellness training sessions with middle-aged women requires a revision of attitudes towards various factors that can affect performance [14]. Due to hormonal changes occurring in women aged 45-50, it becomes necessary to take into account not only the dosage and duration of exercise complexes, but also the time of training [27]. Since the «internal clock» (biorhythms) of the body in the morning and in the evening can have different effects on increasing muscle mass and reducing the percentage of body fat, provided that physical activity is performed, the study helps to navigate the choice of physical exercises.

In experimental group No. 1, in which women engaged in complex physical exercises for 9 months from 9 to 10 a.m. (cardio load in the first part of classes, coordination and strength exercises in the main part of classes, joint mobility exercises in the final part of classes), positive changes in endurance indicators were recorded, physical performance and body mass index. At the same time, there were no significant changes in flexibility and strength in this group. Changes in the level of endurance remained at the level of uncertainty. The results obtained allow us to recommend that people who use morning workouts increase the percentage of exercises in the training program that are aimed at joint mobility and muscle strength development. Based on the data obtained, it is possible to recommend morning workouts to people who want to improve physical performance and endurance, as well as those who need to reduce body weight.

In experimental group No. 2, engaged in a similar program in the evening (from 18 to 19 hours), significant improvements in relative strength and body mass index were recorded. The women involved in group 2 had more impressive results, however, changes in mobility indicators in joints, in the 1000 m run and in the Harvard step test remained at the level of uncertainty. The results obtained allow us to recommend people who use evening workouts to increase the percentage of cardio load if this indicator is lagging behind the specified norm.

Despite the fact that some studies show that favorable conditions are created in the morning for weight loss, and evening workouts are more effective for increasing muscle mass, there are nuances that consist in the need to use one of the workouts for the comprehensive development of physical qualities, physical improvement and wellness [2; 5; 11]. A comparison of the observed groups before the start of the pedagogical experiment and the determination of their uniformity by gender, age and level of physical fitness indicates the fact that the same training programs performed at different times of the day can have a different training effect. The hypothesis put forward at the beginning of the study was confirmed. The health-improving effect of regular training sessions for women aged 45-50 years can be significant, but it may differ depending on the time of classes, which may become the basis for reviewing the program of classes held at different times of the day for better effectiveness.

Conclusions

1. Provided that the same training program of complex physical exercises is followed, women aged 45-50 years have a different training effect in morning and evening groups. In the case when it is necessary to purposefully develop physical qualities, it is necessary to take into account the time of training and decide on the dosage of special exercises or change the schedule of training sessions.

2. Comprehensive training sessions for women 45-50 years old, performed in the morning (from 8 to 9 o'clock), can be effective for improving physical performance and reducing body weight. Comprehensive training sessions for middle-aged women, performed in the evening (from 18 to 19 hours), can be effective for developing strength and reducing body weight.

3. Regardless of the time of physical exercises, they have a healing effect on the body in the form of weight loss. The conducted research needs additional study. In particular, it is not known what effect of complex physical exercises in the morning and evening hours can be observed with an increase in training time, as well as in the long term with the continuation of the training process for more than 9 months.

Conflict of interest. The authors state that there is no conflict of interest.

Джерела та література

1. Amanat, S., Harry, S., Dianatinasab, A., Farway, M. and Dianatinasab, M. (2020). Exercise and type 2 diabetes. *Achievements in experimental medicine and biology,* 2, 91-105. Doi: https://doi.org/10.1007/978-981-15-1792-1_6
2. Baraban, R.B., Jr., Duncan, MU, Dalbo, VJ, Tucker, P.S., and Fanning, A.S. (2017). The impact of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. *British Journal of Sports Medicine,* 51, 494-503. https://doi.org/10.1136/bjsports-2015-095841

References

1. Amanat, S., Harry, S., Dianatinasab, A., Farway, M. and Dianatinasab, M. (2020). Exercise and type 2 diabetes. *Achievements in experimental medicine and biology,* 2, 91-105. Doi: https://doi.org/10.1007/978-981-15-1792-1_6
2. Baraban, R.B., Jr., Duncan, MU, Dalbo, VJ, Tucker, P.S., and Fanning, A.S. (2017). The impact of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. *British Journal of Sports Medicine,* 51, 494-503. https://doi.org/10.1136/bjsports-2015-095841

3. Boutari C., Mantzoros C. S. (2022). A 2022 update on the epidemiology of obesity and a call to action: as its twin COVID-19 pandemic appears to be receding, the obesity and dysmetabolism pandemic continues to rage on. *Metabolism,* 133, 155-217.
4. Carla E. Cox (2017), Role of Physical Activity for Weight Loss and Weight Maintenance. *Diabetes Spectr.* No. 30 (3). P. 157-160. https://doi.org/10.2337/ds17-0013
5. Chingkwan, N. K. P, Giles-Courtney, B. and Knuiman, M. (2008). Accessibility and connectivity in physical activity research: the impact of missing pedestrian data. *Preventive medicine,* 46, 41-45. https://doi.org/10.1016/j.ypmed.2007.08.004
6. Cook, G. (2003). *Athletic Body in Balance 1st Edition*. Human Kinetics Publ. 1 edition. 232 p.
7. Cook, G. (2011). *Movement. Functional Movement Systems* – Screening, Assessment, Corrective Strategies.
8. Couvert, A., Goumy, L., Maillard, F. (2024). Effects of a Cycling versus Running HIIT Program on Fat Mass Loss and Gut Microbiota Composition in Men with Overweight/Obesity. *Medicine & Science in Sports & Exercise,* 56(5), 839-850. doi: 10.1249/MSS.0000000000003376
9. Da Silva-Grigoletto Marzo, E., Marceli, M. A. Mesquita, Aragão-Santos, José C., Marta S. Santos, Resende-Neto, Antônio G., De Santana, Josimari M., Behm? David G. (2019). Functional Training Induces Greater Variety and Magnitude of Training Improvements than Traditional Resistance Training in Elderly Women. *Journal of Sports Science and Medicine,* 18, 789-797.
10. Duan, Y., Lu, G. (2024). A Randomized Controlled Trial to Determine the Impact of Resistance Training versus Aerobic Training on the Management of FGF-21 and Related Physiological Variables in Obese Men with Type 2 Diabetes Mellitus. *Journal of Sports Science and Medicine,* 23, 495-503. doi: https://doi.org/10.52082/jssm.2024.495
11. Dyar, K., Ciciliot, S., Wright, L. (2014). Muscle insulin sensitivity and glucose metabolism are controlled by the intrinsic muscle clock. *Molecular Metabolism,* 3(1), 29-41. https://doi.org/10.1016/j.molmet.2013.10.005
12. Egan, B., Zierath, J. (2013), Exercise Metabolism and the Molecular Regulation of Skeletal Muscle Adaptation. *Cell Metabolism*. No. 2. P. 162-184 doi: http://dx.doi.org/10.1016/j.cmet.2012.12.012
13. Figueiredo V.C., de Salles B.F., Trajano G.S. (2018). Volume for Muscle Hypertrophy and Health Outcomes: The Most Effective Variable in Resistance Training. *Sports Medicine,* 48, 499-505.
14. Fried, L.P., Tangen, C.M., Walston, J., Newman, A.B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W.J., Burke, G., McBurnie, M.A., Cardiovascular Health, Study Collaborative Research, G. (2001). Frailty in older adults: evidence for a phenotype. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences,* 56, 146-156.
15. Garcia-Hermoso, A., Cavero-Redondo, I., Ramirez-Velez, R., Ruiz, J.R., Ortega, F.B., Lee D.C., Martinez-Vizcaino V. (2018). Muscular Strength as a Predictor of All-Cause Mortality in an Apparently Healthy Population: A Systematic Review and Meta-Analysis of Data From Approximately 2 Million Men and Women. *Archives of Physical Medicine and Rehabilitation*, 99, 2100-2113.
16. Hafizi Mari, M., Nosratabadi, S., Yazdi, N., Kasrai, R., Abbasi Senjedari, Z., Khatami, R. (2023). The effect of exercise on inflammatory markers in women with PCOS: a systematic review and meta-analysis of randomized trials. *International Journal of Clinical Practice,* 3, 1-9. https://doi.org/10.1155/2023/3924018
17. Halal, P., Andersen, L., Bull, F. (2012). Physical Activity Working Group Global Levels of Physical Activity: Progress in observation, pitfalls and Prospects *Lancet,* 380, 247-257

3. Boutari C., Mantzoros C. S. (2022). A 2022 update on the epidemiology of obesity and a call to action: as its twin COVID-19 pandemic appears to be receding, the obesity and dysmetabolism pandemic continues to rage on. *Metabolism,* 133, 155-217.
4. Carla E. Cox (2017), Role of Physical Activity for Weight Loss and Weight Maintenance. *Diabetes Spectr.* No. 30 (3). P. 157-160. https://doi.org/10.2337/ds17-0013
5. Chingkwan, N. K. P, Giles-Courtney, B. and Knuiman, M. (2008). Accessibility and connectivity in physical activity research: the impact of missing pedestrian data. *Preventive medicine,* 46, 41-45. https://doi.org/10.1016/j.ypmed.2007.08.004
6. Cook, G. (2003). *Athletic Body in Balance 1st Edition*. Human Kinetics Publ. 1 edition. 232 p.
7. Cook, G. (2011). *Movement. Functional Movement Systems* – Screening, Assessment, Corrective Strategies.
8. Couvert, A., Goumy, L., Maillard, F. (2024). Effects of a Cycling versus Running HIIT Program on Fat Mass Loss and Gut Microbiota Composition in Men with Overweight/Obesity. *Medicine & Science in Sports & Exercise,* 56(5), 839-850. doi: 10.1249/MSS.0000000000003376
9. Da Silva-Grigoletto Marzo, E., Marceli, M. A. Mesquita, Aragão-Santos, José C., Marta S. Santos, Resende-Neto, Antônio G., De Santana, Josimari M., Behm? David G. (2019). Functional Training Induces Greater Variety and Magnitude of Training Improvements than Traditional Resistance Training in Elderly Women. *Journal of Sports Science and Medicine,* 18, 789-797.
10. Duan, Y., Lu, G. (2024). A Randomized Controlled Trial to Determine the Impact of Resistance Training versus Aerobic Training on the Management of FGF-21 and Related Physiological Variables in Obese Men with Type 2 Diabetes Mellitus. *Journal of Sports Science and Medicine,* 23, 495-503. doi: https://doi.org/10.52082/jssm.2024.495
11. Dyar, K., Ciciliot, S., Wright, L. (2014). Muscle insulin sensitivity and glucose metabolism are controlled by the intrinsic muscle clock. *Molecular Metabolism,* 3(1), 29-41. https://doi.org/10.1016/j.molmet.2013.10.005
12. Egan, B., Zierath, J. (2013), Exercise Metabolism and the Molecular Regulation of Skeletal Muscle Adaptation. *Cell Metabolism*. No. 2. P. 162-184 doi: http://dx.doi.org/10.1016/j.cmet.2012.12.012
13. Figueiredo V.C., de Salles B.F., Trajano G.S. (2018). Volume for Muscle Hypertrophy and Health Outcomes: The Most Effective Variable in Resistance Training. *Sports Medicine,* 48, 499-505.
14. Fried, L.P., Tangen, C.M., Walston, J., Newman, A.B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W.J., Burke, G., McBurnie, M.A., Cardiovascular Health, Study Collaborative Research, G. (2001). Frailty in older adults: evidence for a phenotype. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences,* 56, 146-156.
15. Garcia-Hermoso, A., Cavero-Redondo, I., Ramirez-Velez, R., Ruiz, J.R., Ortega, F.B., Lee D.C., Martinez-Vizcaino V. (2018). Muscular Strength as a Predictor of All-Cause Mortality in an Apparently Healthy Population: A Systematic Review and Meta-Analysis of Data From Approximately 2 Million Men and Women. *Archives of Physical Medicine and Rehabilitation*, 99, 2100-2113.
16. Hafizi Mari, M., Nosratabadi, S., Yazdi, N., Kasrai, R., Abbasi Senjedari, Z., Khatami, R. (2023). The effect of exercise on inflammatory markers in women with PCOS: a systematic review and meta-analysis of randomized trials. *International Journal of Clinical Practice,* 3, 1-9. https://doi.org/10.1155/2023/3924018
17. Halal, P., Andersen, L., Bull, F. (2012). Physical Activity Working Group Global Levels of Physical Activity: Progress in observation, pitfalls and Prospects *Lancet,* 380, 247-257

18. Kolberg, S.R., Segal, R.J. Fernhall, B. American College of Sports Medicine, American Diabetes Association (2010). Exercise and Type 2 Diabetes: The American College of Sports Medicine and the American Diabetes Association: Joint Position Statement. *Diabetes treatment*, 33, 147-167.
19. Lohne-Seiler, H., Torstveit, M.K., Anderssen, S.A. (2013). Traditional versus functional strength training: effects on muscle strength and power in the elderly. *Journal of Aging and Physical Activity,* 21, 51-70.
20. Loturco, I., Dello Iacono, A., Nakamura, F. Y., Freitas, T. T., Boullosa, D., Valenzuela, P. L., Pereira, L. A., & McGuigan, M. R. (2021). The Optimum Power Load: A Simple and Powerful Tool for Testing and Training. *International Journal of Sports Physiology and Performance,* 17(2), 151-159. doi: https://doi.org/10.1123/ijspp.2021-0288
21. Mingyue, Y, Hansen, L, Mingyang, B. (2024). Is low-volume high-intensity interval training a time-efficient strategy to improve cardiometabolic health and body composition? A meta-analysis. *Applied Physiology, Nutrition, and Metabolism,* 49(3), 273-292. doi: https://doi.org/10.1139/apnm-2023-0329
22. O'Gorman, D.J., Carlson, H.K., McQuaid, S. (2006). Physical exercise increases insulin-stimulated glucose utilization and GLUT4 (SLC2A4) protein content in patients with type 2 diabetes. *Diabetology,* 49, 2983-2992.
23. Suissi, N., Gauthier, A., Sesbue, B., Larue, J. and Davenne, D. (2002), The effect of regular workouts at the same time of day on daily fluctuations in muscle performance. *Journal of Sports Sciences,* 20(11), 929-937. https://doi.org/10.1080/026404102320761813
24. Sultana, R. N., Sabag, A., Keating, S. E., Johnson, N. A. (2019). The Effect of Low-Volume High-Intensity Interval Training on Body Composition and Cardiorespiratory Fitness: A Systematic Review and Meta-Analysis. *Sports Medicine,* 49, 1687-1721. doi: 10.1007/s40279-019-01167-w.
25. Verboven, K., Stinkens, R., Hansen, D. (2018). Adrenergically and non-adrenergically mediated human adipose tissue lipolysis during acute exercise and exercise training. *Clin Sci (Lond),* 132(15), 1685-1698. doi: https://doi.org/10.1042/CS20180453
26. Woods, K., Bishop, P., Jones, E. (2007). Warm-up and stretching in the prevention of muscular injury. *Sports Medicine,* 37(12), 1089-1099. doi: https://doi.org/10.2165/00007256-200737120-00006
27. Xiangui, Z., Jiao, J, Liu, Y., Li, H. (2024). The Release of Lipolytic Hormones during Various High-Intensity Interval and Moderate-Intensity Continuous Training Regimens and Their Effects on Fat Loss. *Journal of Sports Science and Medicine,* 23, 559-570. doi: https://doi.org/10.52082/jssm.2024.559
28. Zhang, H. F., Tong, T. K., Kong, Z. (2021). Exercise training-induced visceral fat loss in obese women: The role of training intensity and modality. *Scandinavian Journal of Medicine & Science in Sports*, No. 31, 30-43. doi: https://doi.org/10.1111/sms.13803
29. Zhang, H. F., Tong, T. K., Qiu, W. F. (2015). Effect of High-Intensity Interval Training Protocol on Abdominal Fat Reduction in Overweight Chinese Women: A Randomized Controlled Trial. *Kinesiology,* 47, 57-66.
30. Zhang, H., Tong, T. K., Qiu, W. (2017). Comparable Effects of High-Intensity Interval Training and Prolonged Continuous Exercise Training on Abdominal Visceral Fat Reduction in Obese Young Women. *Journal of Diabetes Research,* Article ID 5071740. doi: https://doi.org/10.1155/2017/5071740

18. Kolberg, S.R., Segal, R.J. Fernhall, B. American College of Sports Medicine, American Diabetes Association (2010). Exercise and Type 2 Diabetes: The American College of Sports Medicine and the American Diabetes Association: Joint Position Statement. *Diabetes treatment*, 33, 147-167.
19. Lohne-Seiler, H., Torstveit, M.K., Anderssen, S.A. (2013). Traditional versus functional strength training: effects on muscle strength and power in the elderly. *Journal of Aging and Physical Activity,* 21, 51-70.
20. Loturco, I., Dello Iacono, A., Nakamura, F. Y., Freitas, T. T., Boullosa, D., Valenzuela, P. L., Pereira, L. A., & McGuigan, M. R. (2021). The Optimum Power Load: A Simple and Powerful Tool for Testing and Training. *International Journal of Sports Physiology and Performance,* 17(2), 151-159. doi: https://doi.org/10.1123/ijspp.2021-0288
21. Mingyue, Y, Hansen, L, Mingyang, B. (2024). Is low-volume high-intensity interval training a time-efficient strategy to improve cardiometabolic health and body composition? A meta-analysis. *Applied Physiology, Nutrition, and Metabolism,* 49(3), 273-292. doi: https://doi.org/10.1139/apnm-2023-0329
22. O'Gorman, D.J., Carlson, H.K., McQuaid, S. (2006). Physical exercise increases insulin-stimulated glucose utilization and GLUT4 (SLC2A4) protein content in patients with type 2 diabetes. *Diabetology,* 49, 2983-2992.
23. Suissi, N., Gauthier, A., Sesbue, B., Larue, J. and Davenne, D. (2002), The effect of regular workouts at the same time of day on daily fluctuations in muscle performance. *Journal of Sports Sciences,* 20(11), 929-937. https://doi.org/10.1080/026404102320761813
24. Sultana, R. N., Sabag, A., Keating, S. E., Johnson, N. A. (2019). The Effect of Low-Volume High-Intensity Interval Training on Body Composition and Cardiorespiratory Fitness: A Systematic Review and Meta-Analysis. *Sports Medicine,* 49, 1687-1721. doi: 10.1007/s40279-019-01167-w.
25. Verboven, K., Stinkens, R., Hansen, D. (2018). Adrenergically and non-adrenergically mediated human adipose tissue lipolysis during acute exercise and exercise training. *Clin Sci (Lond),* 132(15), 1685-1698. doi: https://doi.org/10.1042/CS20180453
26. Woods, K., Bishop, P., Jones, E. (2007). Warm-up and stretching in the prevention of muscular injury. *Sports Medicine,* 37(12), 1089-1099. doi: https://doi.org/10.2165/00007256-200737120-00006
27. Xiangui, Z., Jiao, J, Liu, Y., Li, H. (2024). The Release of Lipolytic Hormones during Various High-Intensity Interval and Moderate-Intensity Continuous Training Regimens and Their Effects on Fat Loss. *Journal of Sports Science and Medicine,* 23, 559-570. doi: https://doi.org/10.52082/jssm.2024.559
28. Zhang, H. F., Tong, T. K., Kong, Z. (2021). Exercise training-induced visceral fat loss in obese women: The role of training intensity and modality. *Scandinavian Journal of Medicine & Science in Sports*, No. 31, 30-43. doi: https://doi.org/10.1111/sms.13803
29. Zhang, H. F., Tong, T. K., Qiu, W. F. (2015). Effect of High-Intensity Interval Training Protocol on Abdominal Fat Reduction in Overweight Chinese Women: A Randomized Controlled Trial. *Kinesiology,* 47, 57-66.
30. Zhang, H., Tong, T. K., Qiu, W. (2017). Comparable Effects of High-Intensity Interval Training and Prolonged Continuous Exercise Training on Abdominal Visceral Fat Reduction in Obese Young Women. *Journal of Diabetes Research,* Article ID 5071740. doi: https://doi.org/10.1155/2017/5071740

Надійшла до друку 18.12.2024