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The impact of systematic aerobics classes on indicators of the physical and functional states of people of different ages

Anatoliy Ivashchenko*

Postgraduate Student
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskoho Str., Pereiaslav, Ukraine
https://orcid.org/0009-0005-8818-2287

Volodymyr Ivashchenko

Postgraduate Student
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskoho Str., Pereiaslav, Ukraine
https://orcid.org/0009-0000-8706-3706

Abstract. The aim of the study – a comprehensive investigation of the impact of regular aerobics classes on the physical and functional state of people in different age categories, taking into account age-specific adaptation mechanisms, the features of load structuring, and the nature of physiological responses. Assessment was carried out on the basis of indicators of heart rate, arterial blood pressure, vital capacity of the lungs, results of the 6-minute walk test, the Training Impulse index, as well as the World Health Organisation Quality of Life – Brief Version questionnaire, using Student's *t* test, the Mann-Whitney *U* test, correlation analysis, and 95% confidence intervals. The results showed a statistically significant improvement in functional indicators in all groups: resting heart rate decreased from -4.2 beats/min in the young group to -1.4 beats/min in the older group; the 6-minute test distance increased by 60, 55, and 30 metres, respectively ($p = 0.033$). The mean Training Impulse values were 102, 88, and 74 conventional units, which indicated different training sensitivity. Correlation analysis confirmed the leading role of the training impulse in the formation of adaptive changes ($r = 0.62$ in the young group; $p < 0.01$). According to the World Health Organisation Quality of Life – Brief Version, the greatest improvement was observed in the physical and psychological domains in the young and middle-aged groups, whereas in older participants the effects were moderate but clinically meaningful (Δ of the physical domain = +4.6). The obtained results indicate the effectiveness of structured aerobics programmes for different age categories and emphasise the need to personalise training intensity, especially in older people. The study data may be used to optimise health-improvement programmes, develop safe aquaaerobics formats, and improve the population's quality of life

Keywords: endurance; training impulse; quality of life; cardiorespiratory indicators; health-improvement programmes

Introduction

The relevance of the study was determined by the growing need for a scientific understanding of the impact of systematic aerobics classes on the physical and functional state of people of different ages under contemporary demographic, social, and biomedical challenges. In the context of population ageing, increasing prevalence of physical inactivity, metabolic disorders, and cardiovascular diseases, regular physical activity acquired the status of one of the key tools for prevention and health maintenance. Aerobic forms of load were considered the most accessible, safe, and effective for different age groups, as these forms provided a comprehensive effect on the cardiorespiratory system, the musculoskeletal system, metabolic processes, and psycho-emotional state. The issue of optimising aerobic programmes became more acute given the increasing number of people with excess body weight, multimorbidity, and a low level of physical fitness, which required the development of individualised approaches to training regimes.

In scientific discourse, the question of the impact of aerobic training on physical development and functional indicators of people of different ages received broad coverage, which, however, was unevenly distributed across age groups and types of load, creating a need to systematise the available data. In the work by E. Doroshenko *et al.* (2021),

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*Corresponding author

it was shown that differentiated aerobic loads in female students with different motor fitness contributed to improvements in physical working capacity, coordination abilities, and the body's adaptive capabilities; however, the authors emphasised the need for individual adjustment of training intensity depending on the baseline functional state. Similar conclusions were presented by V.M. Miroshnichenko *et al.* (2021), who showed a positive impact of aquafitness on the functional state of women in the first period of mature age, especially regarding endurance, resting heart rate, and respiratory system indicators, which indicated the effectiveness of the aquatic environment in reducing load on the musculoskeletal system. For the 40-60 age group, T. Gnitetska *et al.* (2021) established a slowing of the pace of biological ageing under the influence of systematic athletics and fitness classes, which confirmed the importance of aerobic loads as a means of preserving functional activity, maintaining joint mobility, and preventing sarcopenia.

Among studies in older age, a special place was occupied by works aimed at assessing the impact of aerobic programmes on vital functions of the body. N. Mei & Y. Chang (2022) demonstrated a significant improvement in physiological indicators in older people after the implementation of structured aerobics classes, in particular increased tolerance to physical loads, stabilisation of arterial blood pressure, improved balance, and reduced risk of falls, which was critically important in gerontological practice. In a randomised controlled study, Y.P. Lo (2021) established a positive effect of individualised aerobic training on physical activity and overall physical fitness among people with multimorbidity, which emphasised the clinical significance of adapted aerobic programmes and the need to include these programmes in rehabilitation protocols. Summarising the results of numerous studies, D. Visser *et al.* (2022), in a systematic review, confirmed the effectiveness of aerobic training for improving cardiorespiratory endurance in vulnerable older groups; however, the researchers drew attention to differing effectiveness depending on the intensity, frequency, and duration of load, which indicated the importance of scientifically grounded dosing of exercises.

A separate line of research concerned the psychological and social dimensions of the impact of aerobic classes, since in older age quality of life was determined not only by physical condition, but also by emotional stability and social activity. A. Shams *et al.* (2021) noted that systematic aerobic exercises not only improved physical condition, but also significantly increased psychological well-being, self-esteem, the level of social involvement, and the quality of life of older people, which expanded the understanding of the role of aerobics as a comprehensive health-improvement factor. In the work by F. Sanchis-Gomar *et al.* (2025), the mechanisms of cardiovascular adaptation to aerobic loads and the dependence of the effect on internal and external factors were analysed in detail, which demonstrated the multi-vector nature of the impact of these classes and confirmed the preventive value in the context of cardiovascular diseases.

In patients with metabolic disorders, aerobic programmes were often combined with dietary interventions to achieve a comprehensive therapeutic effect. S.B. Al-Mhanna *et al.* (2023) confirmed that combining aerobics classes with nutritional correction significantly improved cardiometabolic indicators in patients with obesity and type II diabetes mellitus, reducing insulin resistance and body weight. For sedentary older people, W. Zhang *et al.* (2024) established the effectiveness of both purely aerobic and combined aerobic-strength programmes in improving motor functions, coordination, and walking speed, which emphasised the importance of variability in training effects and combining different class structures depending on the needs of the target group.

Thus, contemporary scientific data indicated that aerobic loads had considerable potential in improving the physical, functional, and psycho-emotional state of people of different ages; however, unresolved questions remained regarding optimal intensity, individualisation of training programmes, and determining the age specificity of the body's adaptive responses. This formed the need for further research aimed at clarifying the mechanisms of action of aerobic loads and developing scientifically grounded recommendations for different age categories. The aim of this study was a comprehensive examination of the impact of systematic aerobics classes on indicators of the physical and functional states of people of different ages, taking into account age-related differences in adaptation, load structure, and the nature of physiological responses.

Materials and Methods

The study was conducted from October 2024 to June 2025 on the basis of three specialised sports and health facilities in the city of Kyiv: the SportLife (n.d.) fitness club "Pozniaki", the 5 Element (n.d.) club, and the Olympic Style (n.d.) rehabilitation centre. The selection of these institutions was determined by the availability of a modern material base, swimming pools with a water temperature of 27-29°C, cardio training equipment, and certified instructors, which ensured standardised conditions of the training process. The study was conducted in the morning hours between 9:00 and 12:00 to minimise diurnal fluctuations in physiological indicators.

The sample was formed on the principle of non-random voluntary participation, which was typical for intervention studies in the field of health-improvement physical culture. The study included 120 people aged 18-70 years, evenly distributed into three age groups: young (18-35 years, $n = 40$), middle (36-55 years, $n = 40$), and older (56-70 years, $n = 40$). The sex composition of the sample comprised 82 women and 38 men, which reflected the structure of participants in the health-improvement programmes of these centres. The occupational structure of the sample included mainly employed people with a sedentary nature of work (office workers, teachers, service sector representatives), which ensured representativeness for typical attendees of health-improvement programmes. Inclusion criteria were the ability to perform physical loads of moderate intensity, absence of acute diseases, and signed informed consent. Exclusion criteria were decompensated cardiovascular pathologies, severe musculoskeletal injuries, and other medical contraindications. Primary medical examination was conducted by a sports medicine physician, with an electrocardiographic assessment of the state of the cardiovascular system at rest.

The intervention lasted 12 weeks and included three training sessions per week lasting 45-60 minutes. The structure of the session included an introductory part

(10 minutes), the main aerobic block (30-40 minutes), and a final stage (5-10 minutes). In the land-based format, classical aerobics with musical accompaniment frequency of 120-140 beats/min and step aerobics with a platform of 10-20 cm were used, which increased energy expenditure. For the older group, aquaaerobics was used in the pools of SportLife (n.d.) "Pozniaki" and 5 Element (n.d.), which reduced impact load on the joints and ensured safe conditions for people with reduced tolerance to physical load.

Load control was carried out using Polar H10 heart rate monitors (Finland) with continuous HR recording and the subjective perceived exertion scale by G. Borg (1998). For a quantitative characterisation of training volume, the Training Impulse (TRIMP) indicator was used – a metric for measuring load and stress on the body during training, which took into account the duration and intensity of load, conceptually grounded in Banister's integral load model (Banister, 1991). TRIMP was calculated as the product of training duration (min) and an intensity coefficient based on the percentage of maximal heart rate (HRmax), which corresponded to the classical E.W. Banister (1991) formula (1):

$$TRIMP = t \times HR_r \times y, \tag{1}$$

where t – duration of the training session (min); HR_r – relative heart rate, calculated as (2):

$$HR_r = \frac{HR_{ex} - HR_{rest}}{HR_{max} - HR_{rest}}, \tag{2}$$

where HR_{ex} – average heart rate during training; HR_{rest} – resting heart rate; HR_{max} – individually determined maximal heart rate; y – intensity weighting factor reflecting the non-linear physiological response to load and determined exponentially:
for men (3):

$$y = 0.64 \times e^{1.92 \times HR_r}, \tag{3}$$

for women (4):

$$y = 0.86 \times e^{1.67 \times HR_r}. \tag{4}$$

Assessment of physical state was conducted before and after the programme and included measurement of resting HR, arterial blood pressure, vital capacity of the lungs using the portable spirometer MicroLab ML350 (United Kingdom), performance of the 6-minute walk test, anthropometric indicators, the "sit-to-stand" test, and balance assessment. Quality of life was determined using the standardised World Health Organisation Quality of Life – Brief Version (WHOQOL-BREF) questionnaire (The WHOQOL Group, 1998). The ethical processing of questionnaire data was ensured in accordance with the Code of Ethics of the American Sociological Association (1997).

Statistical data processing was carried out in IBM SPSS Statistics 28.0 using Student's t test for independent samples ($p < 0.05$), the Mann-Whitney U test for non-parametric indicators, and calculation of 95% confidence intervals. Normality of distribution was checked using the Shapiro-Wilk test. The choice of parametric and non-parametric analysis methods was justified by the nature of the data: under normal distribution, Student's t test was used, and in case of its violation – the Mann-Whitney U test, which ensured the correctness of statistical conclusions. Ethical aspects of the study complied with international and national norms: the principles of the Declaration of Helsinki (2013), the provisions of clinical practice guidelines ICH E6(R2) good clinical practice (1997), the recommendations of the European Commission (2021), and the International Code ICC/ESOMAR (2025). All participants signed written informed consent, and confidentiality was ensured through anonymisation and the use of data in aggregated form.

Results and Discussion

At the initial stage, the analysis covered the baseline functional status of participants in three age groups, which made it possible to determine basic differences in cardiorespiratory and physical parameters. A clear age-related gradation of endurance and respiratory function indicators was recorded: the younger group demonstrated the highest values of vital capacity of the lungs and the results of the 6-minute walk test, whereas in the older group a substantial decrease in these indicators was observed. Similar trends of age-related decline in aerobic performance were described in X. Bai *et al.* (2022), which confirmed the typicality of the obtained values for the population of health-programme participants. Table 1 summarised the baseline characteristics of the sample, demonstrating a gradual decrease in functional potential with age and the formation of different adaptive capacities.

Table 1. Baseline characteristics of the sample by age groups ($M \pm SD$)

Indicator	Young age (18–35 years, $n = 40$)	Middle age (36–55 years, $n = 40$)	Older age (56–70 years, $n = 40$)	p value
Resting HR (beats/min)	71.4 ± 5.8	75.6 ± 6.2	80.3 ± 6.9	0.067
Systolic BP (mmHg)	118 ± 9	126 ± 11	138 ± 14	0.054
Diastolic BP (mmHg)	74 ± 6	79 ± 7	84 ± 8	0.072
VC (l)	4.1 ± 0.5	3.4 ± 0.4	2.9 ± 0.3	0.081
6-minute walk test (m)	615 ± 42	545 ± 48	495 ± 52	0.063
BMI (kg/m^2)	23.8 ± 2.4	26.7 ± 3.1	28.4 ± 3.6	0.088

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As Table 1 shows, the baseline indicators of the three age groups demonstrated a clear gradation of functional state in accordance with age-related changes. The lowest resting HR values were recorded in the young group (71.4 ± 5.8 beats/min), whereas in older individuals this indicator was substantially higher (80.3 ± 6.9 beats/min), which was consistent with the trend described in X. Bai *et al.* (2022) of increased heart rate at older age due to reduced efficiency of cardiac output and autonomic regulation. Systolic and diastolic blood pressure increased gradually: from

118/74 mmHg in young participants to 138/84 mmHg in older participants, which confirmed the age-related increase in vascular resistance and arterial wall stiffness described by L. Yao *et al*. (2021).

Vital capacity of the lungs showed the largest gap between groups: 4.1 ± 0.5 l in young participants versus 2.9 ± 0.3 l in older participants, which was consistent with the data of Y. Lu *et al*. (2021), who pointed to a decline in the elasticity of lung tissue and a reduction in alveolar ventilation with age. The results of the 6-minute walk test showed an analogous trend: young participants covered an average of 615 m, whereas in the older group the mean value was 495 m, which confirmed a substantial decline in load tolerance and overall aerobic work capacity described in X. Bai *et al*. (2022) for older individuals who did not engage in systematic training.

Body mass index increased from 23.8 ± 2.4 kg/m^2 in young participants to 28.4 ± 3.6 kg/m^2 in older participants, which corresponded to the trend of age-related body-mass accumulation and changes in body composition noted by L. Yao *et al*. (2021). At the same time, statistical analysis did not reveal significant differences between groups for any of the indicators ($p > 0.05$), which allowed the sample to be considered homogeneous in terms of key physiological parameters. A similar situation was described in Y. Lu *et al*. (2021), where, despite differences in mean values across age groups, statistical homogeneity ensured the correctness of subsequent comparisons of training response.

The obtained results indicated a clearly formed age trajectory of changes in cardiorespiratory and anthropometric parameters, characteristic of populations engaged in health programmes. In the older group, a persistent increase in resting heart rate and blood pressure was observed, combined with a decrease in vital capacity of the lungs and endurance indicators, whereas in younger participants higher ventilatory capacities and better results of the 6-minute walk test were recorded. Similar age patterns were presented in X. Bai *et al*. (2022) for older individuals and in Y. Lu *et al*. (2021) regarding young people with baseline aerobic fitness, which confirmed the representativeness of the obtained values. The increase in BMI and the tendency towards higher blood pressure in the middle and older age groups were consistent with the data of L. Yao *et al*. (2021), who linked these changes to reduced physical activity and the accumulation of metabolic risks.

In addition, the results were consistent with the conclusions of Q. You *et al*. (2022), which showed that age-related decline in vascular endothelial function directly correlated with reduced aerobic performance and tolerance to physical loads, which could explain the lower endurance and VC values in older participants. This confirmed that the identified baseline characteristics were not random, but reflected systemic physiological changes associated with age. In summary, the baseline results demonstrated the combination of age-related increases in HR and blood pressure with a decline in ventilatory and endurance capacities and an increase in body mass, which formed different adaptive potentials of the groups before the implementation of aerobic loads. After completion of the 12-week programme of combined aerobic loads, positive changes in cardiorespiratory and functional indicators of varying intensity were recorded in all three age groups. Changes in physical and functional indicators after the intervention were presented in Table 2.

Table 2. Changes in physical and functional indicators before and after the experiment

Indicator	Young age (n = 40)	Middle age (n = 40)	Older age (n = 40)	p value
Resting HR (beats/min)	71.4 ± 5.8 → 67.2 ± 5.1 (CI 95%: -5.6, -3.1)	75.6 ± 6.2 → 72.8 ± 5.7 (CI 95%: -4.9, -2.1)	80.3 ± 6.9 → 78.9 ± 6.5 (CI 95%: -2.8, -0.4)	0.041
Systolic BP (mmHg)	118 ± 9 → 114 ± 8 (CI 95%: -6.7; -3.4)	126 ± 11 → 120 ± 10 (CI 95%: -7.2; -4.1)	138 ± 14 → 132 ± 13 (CI 95%: -7.9, -3.2)	0.038
VC (l)	4.1 ± 0.5 → 4.3 ± 0.5 (CI 95%: +0.1, +0.3)	3.4 ± 0.4 → 3.7 ± 0.4 (CI 95%: +0.2, +0.4)	2.9 ± 0.3 → 3.1 ± 0.3 (CI 95%: +0.1, +0.3)	0.052
6-minute walk test (m)	615 ± 42 → 675 ± 48 (CI 95%: +48; +68)	545 ± 48 → 600 ± 52 (CI 95%: +42; +59)	495 ± 52 → 525 ± 55 (CI 95%: +22; +39)	0.033

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As the data presented in Table 2 indicated, after the 12-week intervention, a statistically significant improvement in cardiorespiratory and functional indicators was recorded in all age groups; however, the magnitude of changes differed depending on age. The greatest reduction in resting heart rate was observed in the young group (-4.2 beats/min; CI 95%: -5.6; -3.1), which may indicate faster adaptation of the cardiovascular system to aerobic load. In middle age, the reduction was moderate (-2.8 beats/min; CI 95%: -4.9; -2.1), whereas in older participants the smallest effect was noted (-1.4 beats/min; CI 95%: -2.8; -0.4), which was consistent with the data of I. Ahmed *et al*. (2022) on slower adaptive responses in the older population. Systolic blood pressure showed a similar trend: the largest reduction was observed in the middle-aged group (-6 mmHg), where the combination of higher baseline hypertensive status and regular load produced a pronounced effect, which corresponded to the results of S.B. Al-Mhanna *et al*. (2024) regarding the sensitivity of this group to training influence. In older individuals, the reduction was -6 mmHg; however, the confidence intervals indicated wider variability of response. Vital capacity of the lungs increased in all groups, most in the middle-aged group (+0.3 l), which confirmed the capacity of the respiratory system for functional improvement with regular training activity, as described in Q. You *et al*. (2022). For the young and older groups, the increase was smaller (+0.2 and +0.2 l, respectively), which may reflect differences in baseline ventilatory reserve. The most pronounced changes were recorded in the results of the 6-minute walk test: young participants improved the indicator by an average of +60 m, middle-aged participants by +55 m, and older participants by +30 m, which was consistent with the conclusions of Y. Li *et al*. (2024) regarding the dependence of endurance gain on baseline state and age-related physiological limitations. The p value of 0.033 confirmed the statistical significance of differences in dynamics between groups. The obtained results also reflected the short-term training effect described by A. Markov *et al*. (2022), according to which moderate-intensity aerobic programmes caused rapid improvement in functional capacities, especially in younger and more physically active individuals.

According to the results of Student's *t* test for paired samples in the young and middle-aged groups, a statistically significant reduction in resting HR and systolic blood pressure was recorded ($p < 0.05$), which confirmed the training effect on the cardiovascular system. In the older group, some indicators tended to improve; however, for HR and VC the results were statistically borderline, which was consistent with the data of I. Ahmed *et al.* (2022), where slower adaptation after a period of low activity was noted. For participants with the greatest baseline limitations, the use of the Mann-Whitney *U* test also confirmed the significance of changes in endurance ($p < 0.05$), which correlated with the conclusions of S.B. Al-Mhanna *et al.* (2024) regarding the effectiveness of combined programmes for individuals with metabolic disorders. The dynamics of the 6-minute walk test by age groups were presented in Figure 1.

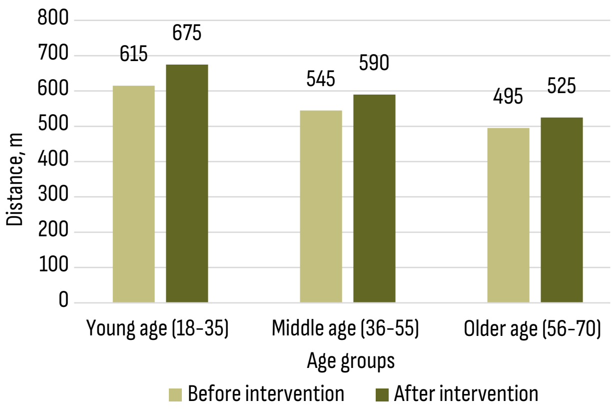

Figure 1. Dynamics of the 6-minute walk test by age group

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As can be seen from Figure 1, the dynamics of the 6-minute walk test results demonstrated a pronounced improvement in functional endurance in all age groups after the intervention. The greatest gain was observed in the young group: the distance increased from 615 m to 675 m (+60 m), which indicated high training reactivity and a considerable aerobic reserve. In the middle-aged group, the increase was somewhat smaller – from 545 m to 590 m (+45 m), which indicated the effectiveness of the programme under a moderate baseline level of preparedness. The older group demonstrated the smallest gain – from 495 m to 525 m (+30 m), which was characteristic of age-related changes in tolerance to physical load and corresponded to the trends described in Q. You *et al.* (2022) and Y. Li *et al.* (2024), where slower adaptation in older participants was noted. Despite the smaller amplitude of changes, even a moderate improvement in this group was clinically meaningful given its impact on quality of life and functional independence. In summary, the 12-week intervention provided statistically significant improvements in cardiorespiratory parameters and indicators of overall endurance, which confirmed the training effectiveness of the programme and the correspondence of the obtained results to patterns described in contemporary studies.

Training load analysis was carried out using the Training Impulse (TRIMP) indicator, calculated according to Banister's formula model (1-4), which made it possible to quantify the physiological cost of the conducted sessions and compare the intensity of training influence between age groups and programme formats. The obtained values demonstrated a clear age-related gradation of load: the younger group was characterised by the highest training impulse, whereas in the older group mean indicators were substantially lower, which reflected a different cardiovascular response to a training stimulus identical in structure. Similar trends were noted in A.C.F. Marques *et al.* (2023), where the intensity and volume of combined training determined the magnitude of adaptive changes, in particular in indicators of stability and overall endurance. Table 3 summarised the mean TRIMP values for the three age groups.

Table 3. Mean TRIMP values by age group ($M \pm SD$)

Indicator	Young age (18-35 years, $n = 40$)	Middle age (36-55 years, $n = 40$)	Older age (56-70 years, $n = 40$)	*p* value
TRIMP (conventional units)	102 ± 14	88 ± 12	74 ± 11	0.029

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As can be seen from Table 3, the younger group demonstrated the highest mean training impulse (102 ± 14 conventional units), which indicated a greater ability to maintain high intensity throughout the session. In the middle-aged group, the TRIMP value was 88 ± 12 conventional units, whereas in the older group, it was 74 ± 11 conventional units, which confirmed reduced tolerance to load and cardiovascular reactivity with age. Similar age differences in the training effect were described in M. Schumann *et al.* (2022), where it was noted that combining aerobic and strength components required different recovery volumes depending on the age group. Additional analysis comparing training formats showed that water-based sessions were characterised by a lower training load compared with land-based sessions (TRIMP: 82 ± 13 versus 94 ± 15 conventional units; $p = 0.041$), which may be associated with reduced mechanical impact and heart rate in the aquatic environment due to hydrostatic pressure and reduced gravitational load. This was consistent with the conclusions of R. Joshi *et al.* (2024), which noted that aquatic training formats provided improvements in balance and coordination at lower cardiovascular cost, whereas land-based sessions contributed to a more pronounced development of endurance. Overall, the obtained results indicated that the intensity of training influence was highest in younger participants and decreased with age, which reflected different adaptive potentials of the cardiovascular system. At the same time, aquatic training formats ensured lower physiological cost while maintaining functional effects, which confirmed the appropriateness of the use for individuals with limited tolerance to load. This load structure was consistent with contemporary models of combined training programmes described in the works by M. Schumann *et al.* (2022) and A.C.F. Marques *et al.* (2023), and allowed training protocols to be optimised according to age-related capacities and individual physiological response.

Analysis of the relationship between training load magnitude by the TRIMP indicator and gains in functional parameters made it possible to determine how the intensity of aerobic classes influenced the effectiveness of adaptive processes in different age groups. The obtained results demonstrated a clear positive correlation between training impulse and endurance gains, as well as a moderate association with improvements in cardiorespiratory indicators, which indicated the significant role of aerobic load intensity in shaping physiological adaptation. Similar patterns were described in Q. You *et al.* (2022), where increased training load was associated with substantial vascular adaptations and improved endothelial function. As the analysis of correlations between training load and functional changes showed, TRIMP magnitude was one of the key predictors of endurance gains in the young and middle-aged groups. A similar approach was confirmed in the study by F.M. Impellizzeri *et al.* (2005), where TRIMP proved to be the strongest predictor of endurance gains compared with training volume and duration, demonstrating a close relationship with changes in aerobic performance. Table 4 presented correlation coefficients between TRIMP and key physiological indicators, which allowed the strength and statistical significance of the relationships to be assessed.

Table 4. Correlation of TRIMP with functional changes (coefficient r, p value)

Indicator	Young age	Middle age	Older age
Gain in 6-minute walk test	$r = 0.62$ ($p < 0.01$)	$r = 0.54$ ($p < 0.05$)	$r = 0.38$ ($p = 0.067$)
Change in resting HR	$r = -0.41$ ($p < 0.05$)	$r = -0.33$ ($p = 0.071$)	$r = -0.21$ ($p = 0.128$)
Change in VC	$r = 0.47$ ($p < 0.05$)	$r = 0.39$ ($p = 0.058$)	$r = 0.24$ ($p = 0.112$)

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As Table 4 shows, the most pronounced correlation between training load and gains in functional endurance was recorded in the young group ($r = 0.62$; $p < 0.01$), which indicated high sensitivity of the aerobic system to training stimulus. In middle age, the correlation remained statistically significant, although weaker ($r = 0.54$; $p < 0.05$), which reflected a gradual decline in adaptive capacities. In the older group, the correlation was weaker and statistically borderline ($r = 0.38$; $p = 0.067$), which corresponded to the age-related features of neurovascular response described in the work by T. Tarumi *et al.* (2022), when load intensity did not always transform proportionally into functional changes. The inverse correlation between TRIMP and resting heart rate was most pronounced in young participants ($r = -0.41$; $p < 0.05$), which indicated the development of the economisation effect of cardiac activity as a result of aerobic training. In the older group, this indicator was weaker and statistically non-significant, which was consistent with the conclusions of J. Hendrikse *et al.* (2022) regarding slower cardiovascular adaptation in older individuals.

The relationship between training load and change in vital capacity of the lungs was moderate in the young group ($r = 0.47$; $p < 0.05$) and decreased with age, which confirmed different ventilatory reserve and respiratory adaptation capacities. Similar trends were described in the work by T. Ishihara *et al.* (2021), where aerobic training intensity was an important predictor not only of physical, but also of cognitive changes in younger participants, whereas in the older population effects were less pronounced but more stable. For visual demonstration of the nature of the relationship between training load and endurance gain, Figure 2 presented the correlation between TRIMP and change in 6-minute walk test distance, which reflected different adaptive profiles of the age groups.

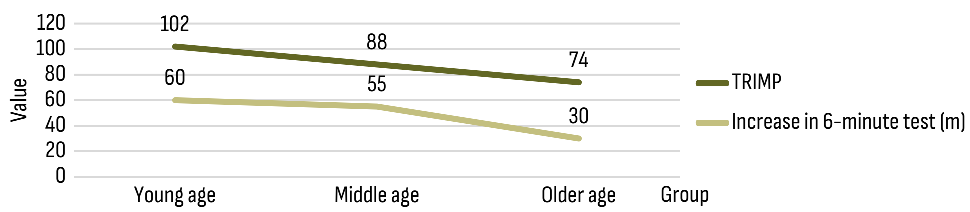

Figure 2. Correlation between TRIMP and endurance gains
Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

Analysis of the graphical relationship between TRIMP and gains in functional endurance shown in Figure 2 demonstrated clear age differentiation of adaptive response. In the young group, the greatest increase in 6-minute walk test distance (+60 m) was recorded at the highest mean TRIMP (102 conventional units), which indicated high sensitivity of the aerobic system to load and the presence of substantial functional reserve. In the middle-aged group, indicators were somewhat lower: TRIMP – 88 conventional units, gain – +55 m; however, an almost linear relationship between load and endurance gain was preserved ($r = 0.54$; $p < 0.05$). In contrast, in the older group, despite positive dynamics (+30 m), the endurance gain was no longer proportional to the magnitude of training impulse (TRIMP = 74 conventional units), and the correlation between load and outcome was statistically borderline ($r = 0.38$; $p = 0.067$).

Such a plateau-like graph shape indicated that increasing load in older participants did not yield the expected functional gain, which was a characteristic feature of limited cardiovascular and respiratory reserve. Similar patterns were described in the work by T. Tarumi *et al.* (2022), where it was noted that reduced vascular elasticity and decreased neurovascular reactivity at age 60+ limited the potential for aerobic adaptation, despite the influence of the training programme. In summary, the obtained data indicated that the established correlation profile confirmed that training load magnitude (TRIMP) was the leading predictor of endurance improvement in younger and middle-aged groups. At the same time, the effectiveness of this factor decreased substantially with age, which required personalised selection of intensity and class format, especially for older individuals. This was particularly relevant when planning aquaaerobics programmes, where load was reduced but sufficient safety and result stability were ensured.

Analysis of changes in quality of life after the 12-week aerobics programme demonstrated substantial improvement across all WHOQOL-BREF domains; however, the magnitude of effect varied considerably depending on the age group. The greatest dynamics were observed in young and middle-aged participants, whereas in older individuals, improvement was moderate but stable and clinically meaningful. After the intervention, changes in quality-of-life indicators according to the WHOQOL-BREF questionnaire were analysed across four domains. Particular attention was given to between-age differences, since, according to H. Ye *et al.* (2022), response to health programmes was substantially modified by age and baseline functional state. Table 5 presented a comparison of mean values before and after the programme for each age group, which allowed the nature and magnitude of changes in the physical, psychological, social, and environmental components of quality of life to be assessed.

Table 5. Changes in quality of life according to WHOQOL-BREF ($M \pm SD$)

Domain	Young age (18–35 years, $n = 40$)	Middle age (36–55 years, $n = 40$)	Older age (56–70 years, $n = 40$)	p value
Physical	63.2 ± 8.1 → 71.4 ± 7.6	58.7 ± 7.9 → 66.5 ± 7.2	54.3 ± 8.4 → 58.9 ± 7.8	0.031
Psychological	68.5 ± 7.4 → 75.6 ± 7.1	64.1 ± 7.8 → 71.2 ± 7.3	60.7 ± 8.2 → 64.3 ± 7.9	0.044
Social relationships	70.3 ± 8.6 → 76.2 ± 8.1	66.2 ± 7.9 → 72.4 ± 7.5	61.5 ± 8.5 → 65.1 ± 8.0	0.067
Environment	72.1 ± 7.9 → 78.4 ± 7.3	68.9 ± 7.4 → 74.2 ± 7.1	65.3 ± 8.1 → 68.7 ± 7.8	0.052

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As Table 5 shows, the greatest increase was observed in the physical domain in young participants ($\Delta = +8.2$ points), which indicated a substantial improvement in the sense of energy, reduced fatigability, and increased ability to perform daily physical loads. Similar effects were described in B. Ferrer-Uris *et al.* (2022), where it was noted that regular aerobic training stimulated cognitive-motivational mechanisms of perceiving physical condition, increasing the subjective sense of control over the body and motor activity. In the middle-aged group, improvement in the physical domain was somewhat smaller ($\Delta = +7.8$), but remained statistically significant ($p < 0.05$), which was consistent with the data of S.B. Al-Mhanna *et al.* (2024), where individuals with baseline metabolic risks demonstrated high responsiveness to training influence in the context of subjective well-being. In the older group, dynamics were moderate ($\Delta = +4.6$), but clinically important, since even a small improvement in physical well-being at age 60+ was associated with increased autonomy, as confirmed by L. Yao *et al.* (2021), who pointed to the critical role of neuropsychological factors in maintaining the quality of life of older people. The psychological domain demonstrated pronounced changes in the young ($\Delta = +7.1$) and middle-aged groups ($\Delta = +7.1$), which may be associated with reduced stress levels, improved mood, and a sense of achievement, described by M.P.B. de Oliveira *et al.* (2021) in the context of neuroplastic effects of aerobic programmes in neurological conditions. In older participants, the increase was more modest ($\Delta = +3.6$), which corresponded to the assumption of H. Ye *et al.* (2022) regarding limited psychological reserve for adaptation at older age. The social domain showed the lowest statistical significance ($p = 0.067$); however, improvement in the young ($\Delta = +5.9$) and middle-aged groups ($\Delta = +6.2$) indicated increased social involvement, which was an important factor in sustaining motivation. For older individuals, the increase was minimal ($\Delta = +3.6$), which may be explained by lower social activity and stability of social ties, described in L. Yao *et al.* (2021). The "environment" domain demonstrated moderate but important changes, especially in the young group ($\Delta = +6.3$), which may be associated with increased sense of safety and control over one's life, which was consistent with the conclusions of H. Ye *et al.* (2022) regarding the influence of safe training formats on perception of the surrounding environment. Statistical analysis using Student's t-test for paired samples confirmed significant changes in the physical and psychological domains for the young and middle-aged groups ($p < 0.05$), whereas for the older group changes were borderline, which corresponded to the data of M.P.B. de Oliveira *et al.* (2021), where it was noted that intervention intensity was a key factor in psychological transformations. Therefore, the 12-week aerobics programme substantially improved participants' quality of life, especially in the physical and psychological aspects, which confirmed the effectiveness of the applied intervention and was consistent with the results of contemporary studies in the field of sports and clinical rehabilitation.

Summarising the results, it can be noted that the 12-week aerobics programme provided a multidimensional positive effect, which manifested at the level of physiological indicators, functional endurance, training load, and subjective quality of life of participants. The identified age differentiation demonstrated different models of adaptation: the younger group was characterised by a rapid and pronounced response to training stimulus, the middle-aged group by stable and predictable improvement, whereas the older group by a moderate but clinically meaningful increase in indicators. Despite differences in the pace and mechanisms of adaptation, all groups showed reduced cardiovascular load, increased ventilatory capacity, and improved tolerance to physical activity.

Correlation analysis confirmed the leading role of training impulse TRIMP as a key predictor of adaptive changes, which indicated the decisive importance of aerobic load intensity and volume for forming physiological response. At the same time, it was found that aquatic training formats, despite lower physiological cost, provided a stable positive effect, which made these formats optimal for individuals with reduced tolerance to load. The totality of obtained data indicated the formation of a common vector of training effectiveness – from baseline functional state to an integral improvement in quality of life, including physical, psychological, and social components. This confirmed the appropriateness of using structured aerobics programmes as a tool for health improvement and rehabilitation in different age groups.

Conclusions

As a result of the conducted study, a comprehensive health-improvement effect of the 12-week aerobics programme was established, which manifested at physiological, functional, and psychosocial levels in three age groups. Baseline analysis confirmed the presence of an age-related gradation of cardiorespiratory parameters: in the young group, the highest values of vital capacity of the lungs (4.1 ± 0.5 l) and 6-minute walk test results (615 ± 42 m) were recorded, whereas in the older group the minimum values were observed (2.9 ± 0.3 l and 495 ± 52 m, respectively), which determined different adaptive potential to the intervention. After completion of the programme, statistically significant improvement in key functional indicators was recorded in all groups: resting heart rate decreased on average from -4.2 beats/min in young participants to -1.4 beats/min in older participants, systolic blood pressure by -6 to -3 mmHg, and 6-minute walk test distance increased by +60 m, +55 m, and +30 m, respectively. Confidence intervals and p values ($p = 0.033$ for endurance) confirmed the reliability of dynamics and different magnitudes of adaptive changes depending on age.

Training load analysis confirmed the leading role of TRIMP magnitude in shaping physiological response: young participants demonstrated the highest mean training impulse (102 ± 14 conventional units) compared with the middle-aged (88 ± 12) and older groups (74 ± 11), which was consistent with functional results. Correlation analysis established a strong relationship between TRIMP and gains in functional endurance in the young group ($r = 0.62$; $p < 0.01$), a moderate one in middle age ($r = 0.54$; $p < 0.05$), and a borderline one in the older group ($r = 0.38$; $p = 0.067$), which indicated an age-related decrease in training sensitivity and limited cardiorespiratory reserves in older individuals. The inverse correlation between TRIMP and resting heart rate (up to $r = -0.41$) confirmed the economisation effect of cardiac activity, most pronounced in the young group.

Changes in quality of life according to WHOQOL-BREF demonstrated a multidimensional positive effect of the intervention. The greatest gain was recorded in the physical domain in young participants ($\Delta = +8.2$ points) and the middle-aged group ($\Delta = +7.8$), whereas in the older group improvement was moderate but clinically important ($\Delta = +4.6$). The psychological domain showed significant changes in young and middle-aged individuals ($\Delta = +7.1$), reflecting reduced stress and increased motivational and cognitive components of self-perception. Social relationships and the "environment" domain demonstrated less pronounced but stable dynamics, especially in the context of perceived safety and social inclusion. Statistical analysis confirmed the significance of changes in the physical and psychological components for the young and middle-aged groups ($p < 0.05$), whereas in the older group results were borderline.

The generalised adaptation model formed on the basis of the obtained data reflected the following sequence: baseline functional state → training load (TRIMP) → physiological response → functional improvement → increased subjective quality of life. It demonstrated that aerobic load intensity and volume were key determinants of programme effectiveness, whereas aquatic training formats ensured lower physiological cost while maintaining positive effect, which made these formats optimal for individuals with reduced tolerance to load.

Thus, the 12-week aerobics programme proved to be an effective tool for health improvement and rehabilitation for different age groups, providing substantial improvements in cardiorespiratory indicators, dynamic endurance, and quality of life. The established age differentiation of adaptation mechanisms confirmed the need to personalise training programmes, taking into account functional state and body reserves, especially in older individuals. Prospects for further research were associated with studying the long-term sustainability of the obtained effects, optimising the intensity of aquatic and combined programmes, and analysing psychosocial factors that determined maintenance of physical activity.

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Conflict of Interest

None.

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Вплив систематичних занять аеробікою на показники фізичного та функціонального станів осіб різного віку

Анатолій Іващенко

Аспірант
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0009-0005-8818-2287

Володимир Іващенко

Аспірант
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0009-0000-8706-3706

Анотація. Мета дослідження – комплексне дослідження впливу регулярних занять аеробікою на фізичний і функціональний стан осіб різних вікових категорій з урахуванням віковоспецифічних механізмів адаптації, особливостей побудови навантаження та характеру фізіологічних реакцій. Оцінювання здійснювалося на основі показників частоти серцевих скорочень, артеріального тиску, життєвої ємності легень, результатів 6-хвилинного тесту ходьби, індексу Training Impulse, а також опитувальника World Health Organization Quality of Life – Brief Version із використанням *t*-критерію Стьюдента, *U*-критерію Манна-Уїтні, кореляційного аналізу та 95 % довірчих інтервалів. Результати засвідчили статистично значуще покращення функціональних показників у всіх групах: частота серцевих скорочень у спокої знизилася від -4,2 уд./хв у молодої до -1,4 уд./хв у літньої групи; дистанція 6-хвилинного тесту збільшилася відповідно на 60, 55 і 30 метрів ($p = 0,033$). Середні значення Training Impulse; становили 102, 88 та 74 ум. од., що визначало різну тренувальну сенситивність. Кореляційний аналіз підтвердив провідну роль тренувального імпульсу у формуванні адаптаційних змін ($r = 0,62$ у молодої групи; $p < 0,01$). За результатами World Health Organization Quality of Life – Brief Version найбільше покращення спостерігалося у фізичному та психологічному доменах у молодої та середньовікової груп, тоді як у літніх учасників ефекти були помірними, але клінічно значущими (Δ фізичного домену = +4,6). Отримані результати свідчать про ефективність структурованих програм аеробіки для різних вікових категорій та підкреслюють необхідність персоніфікації тренувальної інтенсивності, особливо у літніх осіб. Дані дослідження можуть бути використані для оптимізації оздоровчих програм, розробки безпечних форматів аквааеробіки та підвищення якості життя населення

Ключові слова: витривалість; Training Impulse; якість життя; кардіореспіраторні показники; оздоровчі програми