Influence of Aerobics Training on Physical Health: The Auxiliary Effect of Sportswear Design on Cardiopulmonary Function and Sports Performance

Chengli Mu

Department of Physical Education, Zibo Polytechnic University, Zibo 255300, Shandong, China

Corresponding author: Chengli Mu (e-mail: m15666707161@163.com)

ABSTRACT This study evaluates the effects of aerobics training on physical health, emphasizing the auxiliary role of sportswear design in cardiopulmonary function and exercise performance. An 8-week controlled experiment was conducted with 20 female aerobics athletes to compare professional gradient compression sportswear with conventional cotton sportswear. The results show that gradient compression sportswear produced significant physiological and biomechanical improvements. Compared with the control group, the experimental group achieved a 13.4% greater increase in maximal oxygen uptake (VO_2max) ($p < 0.001$) and a 14.4% higher lactate threshold. Exercise economy was also improved, with 10.6% lower energy consumption and a 33.3% reduction in muscle vibration energy ($p < 0.001$). Subjective assessments indicated lower ratings of perceived exertion and higher thermal comfort in the compression group ($p < 0.001$). These results confirm that gradient compression sportswear can serve as an effective auxiliary engineering design for enhancing cardiopulmonary adaptation and athletic performance during aerobics training, while also providing quantitative support for high-performance sportswear and wearable monitoring applications.

INDEX TERMS aerobics training, compression sportswear, cardiopulmonary function, athletic performance, wearable sensing

I. INTRODUCTION

With a growing emphasis on health and wellness, aerobics has become a popular form of exercise due to its ability to improve fitness, strength, and aesthetics [1–3]. As a form of moderate-to-high intensity aerobic activity, it effectively enhances cardiopulmonary function, muscle strength, and body composition [4]. Studies have shown that long-term aerobics training can significantly increase maximal oxygen uptake (VO_2max) and reduce resting heart rate, thereby lowering the risk of cardiovascular disease [5–7]. However, the effectiveness of training is also influenced by external factors, notably sportswear design [8–10]. Appropriate sportswear can improve comfort, reduce injury risk, and enhance athletic performance [11,12]. For instance, fabrics with superior heat and moisture management properties can improve endurance by maintaining thermal balance [13,14]. Advanced technologies like compression garments are designed to provide biomechanical support, potentially reducing muscle vibration and improving blood circulation [15,16]. According to Poiseuille's law, external pressure can influence vessel radius, thereby affecting blood flow and oxygen delivery. Similarly, reducing muscle vibration can conserve energy, as muscle vibration energy is a form of non-productive work.

While the benefits of aerobics and advanced sportswear are recognized individually, there is a lack of experimental research quantifying the specific synergistic effects of professional sportswear on aerobics performance. Most studies are descriptive, focusing on material properties without in-depth experimental verification in a sports-specific context. To address this gap, this study conducts a controlled experiment to systematically investigate the auxiliary effect of gradient compression sportswear on the cardiopulmonary function, exercise economy, and subjective experience of aerobics athletes.

II. MATERIALS AND METHODS

A. PARTICIPANTS

Characteristics of subjects: 20 female Aerobics athletes (age 22 ± 3 years, BMI 20 ± 1.5) were recruited, all of whom were national level II athletes, without history of cardiovascular disease, and had been trained for ≥ 3 years. This study has been approved by the Ethics Committee of Zibo Vocational Institute. All participants provided informed consent prior to the study.

B. EXPERIMENTAL DESIGN

Grouping method: a randomized double-blind controlled design was used, and the participants were divided into two groups. The experimental group (n = 10) wear gradient compression clothing (Brand: SKINS A400, 2XU Elite, and CW-X Stabilyx; ankle pressure 20–25 mmHg, RET = 6.2–6.8). By contrast, the control group (n = 10) wear conventional cotton sportswear (breathable RET = 12.5, non-compression design).

C. TRAINING AND TEST PLAN

Training cycle: 8 weeks, 4 times a week, 60 minutes each time. The training content is standardized (including warm up, high-intensity interval training, strength training, and stretching).

Training intensity was maintained at 70%–85% of the maximum heart rate (HRmax), monitored in real-time using a Polar H10 heart rate monitor.

D. DATA COLLECTION AND ANALYSIS

Physiological and subjective data were collected at baseline (week 0), midpoint (week 4), and post-test (week 8).

1) Cardiopulmonary function

(1) Maximum oxygen uptake (VO_2max):

Test method: The Bruce treadmill incremental load scheme was adopted, and oxygen was measured by a gas metabolism analyzer (cosmod K5).

Formula application:

$$\mathrm{VO}_{2\,\max} = \frac{\text{peak oxygen uptake(L/min)}}{\text{weight(kg)}}$$

(2) Blood lactate threshold (LT):

Test method: Earlobe blood samples are collected on a power bicycle with an increasing load of 25W/3 min, and a Biosen C-Line analyzer is used to detect blood lactate concentration.

Judgment criteria: Personalized lactate thresholds were determined using the Dmax method (maximal distance from the lactate curve to a line connecting the first and last data points) and Log-Log transformation. This approach accounts for individual variability in aerobic and anaerobic metabolic responses.

E. EVALUATION OF SPORTS ECONOMY

(1) Energy consumption (E):

Test plan: A 30-min aerobics is performed under a fixed load (70% VO_2max), and energy consumption is calculated through indirect calorimetry.

Formula application:

$$E = \frac{\mathrm{VO}_2 \times 5\ (\mathrm{kcal/L}) \times 30\ (\mathrm{min})}{\mathrm{weight}\ (\mathrm{kg})} \quad (\mathrm{uint}:\ \mathrm{kcal/kg}).$$

(2) Muscle vibration energy

Test equipment: An inertial sensor (Noraxon IMU) is attached to the quadriceps and gastrocnemius muscles to record vertical acceleration (sampling frequency 1,000 Hz).

The formula application is as follows:

$$E_{\mathrm{vib}} = \frac{1}{2}\sum_{i=1}^{n} m_i a_i^2,$$

where m_i denotes the muscle mass, and a_i refers to acceleration.

F. SUBJECTIVE PERCEPTION ASSESSMENT

(1) Subjective Fatigue Scale (RPE): Borg 6-20 scale is used, and scoring is immediately conducted after training.

(2) Thermal Comfort Rating: This test is carried out on a 5-point scale (from 1 = Extremely Uncomfortable to 5 = Extremely Comfortable).

G. STATISTICAL ANALYSIS

An Analysis of Variance (ANOVA) was used to compare the performance between different brands of compression wear, while independent t-tests were used to compare the final results between the experimental and control groups. The significance level was set at $p < 0.05$.

III. RESULTS AND DISCUSSION

A. BASELINE EQUIVALENCE AND DYNAMIC CHANGES OVER TIME

At the start of the intervention (Week 0), baseline measurements confirmed that there were no statistically significant differences between the experimental and control groups across all key physiological and performance metrics ($p > 0.05$ for all variables), as detailed in Table 1. This establishes the homogeneity of the two groups prior to the study. An initial ANOVA confirmed no significant performance variations among the different brands of compression wear ($p > 0.05$ for all key metrics), justifying the aggregation of their data to form the experimental group for primary analysis.

TABLE 1. Baseline Characteristics of Participants (Week 0, Mean ± SD)

Metric	Experimental Group ($n = 10$)	Control Group ($n = 10$)	p-value
VO_2max (mL/kg/min)	45.2 ± 3.1	44.8 ± 3.5	0.79
Lactate Threshold (%VO_2max)	65.4 ± 4.2	66.1 ± 3.9	0.70
Energy Consumption (kcal/kg)	4.8 ± 0.5	4.9 ± 0.4	0.56

B. CARDIOPULMONARY FUNCTION

The experimental group exhibited a markedly greater enhancement in cardiopulmonary capacity. As illustrated in Figure 1, the average improvement in Maximal Oxygen Uptake (VO_2max) for the experimental group was 13.4%, which was significantly higher than the 6.2% gain observed in the control group ($p < 0.001$). Similarly, the Lactate Threshold (LT) saw an average increase of 14.4% in the experimental group, a significantly greater improvement than the 5.6% increase in the control group ($p < 0.001$).

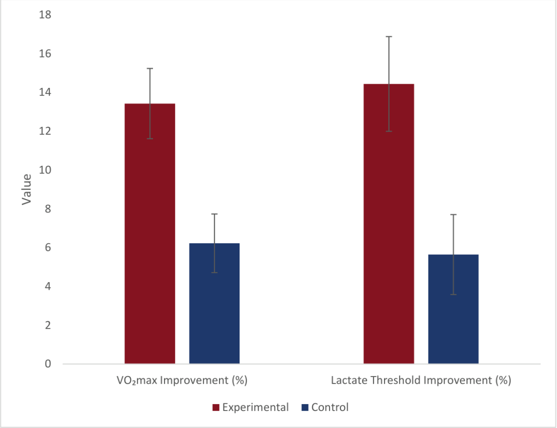

FIGURE 1. Cardiopulmonary Function Improvement

The significant improvement in VO_2max and LT provides strong evidence for the auxiliary role of compression sportswear in enhancing cardiovascular performance. The primary mechanism is likely improved hemodynamics [17,18]. The gradient pressure exerted by the garments, which is highest at the ankle and decreases proximally, is thought to enhance venous return to the heart. This increases cardiac preload and stroke volume, leading to a more efficient cardiac output (Q) and ultimately a higher capacity for oxygen transport and utilization (VO_2max). The elevation of the lactate threshold suggests that this enhanced oxygen delivery delays the onset of anaerobic metabolism, allowing athletes to maintain higher intensity exercise for longer periods before significant fatigue sets in These findings are consistent with studies in other endurance sports, such as running and cycling, which also report the benefits of compression wear on circulatory efficiency [19,20].

C. EXERCISE ECONOMY

The use of compression sportswear led to a significant improvement in exercise economy. As shown in Figure 2, the energy consumption during the standardized aerobics routine was 4.2 kcal/kg for the experimental group, 10.6% lower than the 4.7 kcal/kg consumed by the control group ($p < 0.001$). Furthermore, muscle vibration energy, a measure of non-productive energy expenditure, was drastically reduced to an average of 12.2 J in the experimental group, a 33.3% reduction compared to the 18.3 J recorded for the control group ($p < 0.001$).

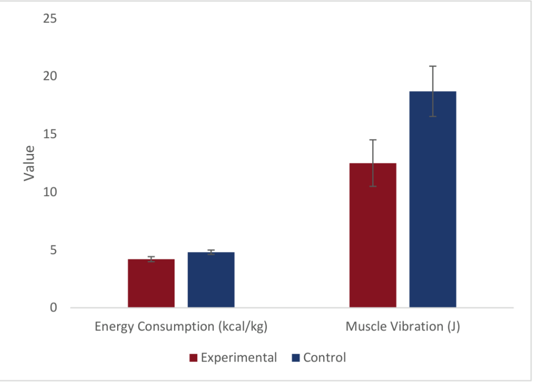

FIGURE 2. Comparison of exercise economy indicators between the experimental and control groups

The observed improvements in exercise economy are attributable to biomechanical factors. The primary contributor is the reduction of soft tissue oscillation. During dynamic movements like jumping and landing in aerobics, muscles vibrate, which dissipates energy that does not contribute to the movement itself. By compressing the muscles, the sportswear acts as an external stabilizer, damping these vibrations and thus conserving metabolic energy [20,21]. This allows a greater proportion of the energy produced by the muscles to be converted into productive mechanical work, making movement more efficient. The lower overall energy consumption is a direct reflection of this improved mechanical efficiency.

D. SUBJECTIVE ASSESSMENT

The subjective feedback from participants correlated strongly with the objective physiological data. As shown in Figure 3, the average Rating of Perceived Exertion (RPE) on the Borg 6-20 scale was significantly lower for the experimental group (12.2, corresponding to "Fairly light") compared to the control group (14.5, corresponding to "Somewhat hard") ($p < 0.001$). In terms of thermal comfort, the experimental group reported a significantly higher average score of 4.3 out of 5 ("Comfortable"), while the control group reported an average of 2.7 ("Slightly uncomfortable") ($p < 0.001$).

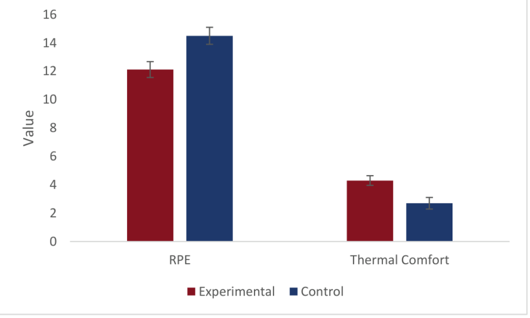

FIGURE 3. Subjective Assessment

The lower perceived exertion in the experimental group is a logical consequence of their improved physiological efficiency. Because their bodies were working more economically and with better oxygen supply, the same absolute workload felt subjectively easier. The superior thermal comfort is directly linked to the material science of the sportswear. The synthetic fabrics used in compression garments have significantly better moisture-wicking properties and lower water vapor resistance (lower RET value) than the cotton worn by the control group. This allows for more efficient sweat evaporation, which is the body's primary mechanism for cooling, thus preventing heat accumulation and maintaining a more comfortable microclimate next to the skin.

While this study provides valuable insights, its limitations must be acknowledged. The sample consisted exclusively of young, female, well-trained athletes, which may limit the generalizability of the findings to male athletes, older adults, or novice exercisers. Additionally, the 8-week duration, while sufficient to observe significant changes, does not capture potential long-term adaptation effects.

Future research should aim to validate these findings in more diverse populations. Investigating the effects of compression wear over longer periods (e.g., 6 months or more) would also be beneficial. Furthermore, with the advent of smart, there is an opportunity to explore dynamic compression garments that can adjust pressure levels in real-time based on an athlete's physiological feedback, potentially offering a personalized and even more effective intervention.

IV. CONCLUSION

This study successfully quantified the significant auxiliary effects of gradient compression sportswear on aerobics training. The experimental results demonstrate that, compared to conventional sportswear, compression garments lead to marked improvements in cardiopulmonary function (higher VO_2max and LT), enhanced exercise economy (lower energy consumption and muscle vibration), and a more positive subjective experience (lower RPE and greater comfort). These findings confirm that scientifically designed sportswear is not merely a passive accessory but an active tool that can optimize physiological responses and enhance athletic performance. This research provides a solid empirical basis for athletes, coaches, and apparel designers to leverage advanced sportswear technology for more effective and efficient health and fitness outcomes.

AUTHOR CONTRIBUTIONS

All work in this study was independently completed by Chengli Mu.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

FUNDING

This research received no external funding.

HUMAN RESEARCH SUBJECTS

This study has been approved by the Ethics Committee of Zibo Vocational Institute. All participants provided informed consent prior to the study.

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] W. Ran, "Exploration on and Thinking about Aesthetic Infiltration in the Aerobics Teaching in Colleges and Universities," Open Access Library Journal, vol. 7, no. 11, pp. 1-6, 2020.
[2] T. Y. Dengyongjia, "Application of physical training in Aerobics Teaching," Contemporary Sports Technology, vol. 9, no. 17, pp. 48-49, 2019.
[3] W. Ran, "Practical Analysis of the Integration Mode of Teaching and Training of Aerobics in Colleges and Universities," Open Access Library Journal, vol. 7, no. 10, pp. 1-6, 2020.
[4] H. Tesnime and A. Faiza, "Corporeality and Socialization, among Aerobics Practitioners at the ISSEP Gafsa," Advances in Applied Sociology, vol. 9, no. 08, pp. 392, 2019.
[5] S. Thapa and R. B. Pattanshetty, "Effect of Chair aerobics as low intensity exercise training on heart rate, blood pressure and six minute walk distance in post coronary artery bypass graft surgery patients through phase I cardiac rehabilitation," Nepalese Heart Journal, vol. 13, no. 1, pp. 19-23, 2016.
[6] L. D. Chul and S. Xuemei, "Relative contributions of cardiorespiratory fitness and body fatness to cardiovascular disease mortality in the aerobics center longitudinal study," CIRCULATION, vol. 125, no. 19, Art. no. E707-E707, 2012.
[7] J. Men and C. Zhao, "Effects of high-intensity interval training on physical morphology, cardiopulmonary function, and metabolic indicators in older adults: a systematic review and meta-analysis," Frontiers in Endocrinology, vol. 16, Art. no. 1526991, 2025.
[8] A. S. Al-Tayyar and M. A. Al Dabbagh, "Saudi Woman's Cycling Trend and Sportswear Preferences," Open Journal of Social Sciences, vol. 9, no. 2, pp. 293-304, 2021.
[9] J. Gao and F. Li, "A Research on the Air Permeability of High Polymer Materials Used to Produce Sports Clothing Fabrics," Fluid Dynamics & Materials Processing, vol. 19, no. 5, pp. 1173-1187, 2022.
[10] S. G. Margret and S. Kavitha, "Dimensional, moisture, and thermal properties of bi-layered knitted fabric for sportswear application," Research Journal of Textile and Apparel, vol. 27, no. 4, pp. 543-559, 2023.
[11] J. Zhou, S. Liu, and Analysis of the dynamic properties of elastic knitted fabric for sportswear: Inverse stress relaxation, "Textile Research Journal," 2019; 89(9):1673-1683.
[12] A. Muposhi and M. Dhurup, "Stemming the sportswear counterfeit tide: Emerging market evidence of rational and normative drivers," Acta Commercii, vol. 20, no. 1, pp. 1-10, 2020.
[13] T. P. Gavin, "Clothing and thermoregulation during exercise," Sports Medicine, vol. 33, pp. 941-947, 2003.
[14] J. K. Davis and P. A. Bishop, "Impact of clothing on exercise in the heat," Sports medicine, vol. 43, pp. 695-706, 2013.
[15] P. Cheng and X. Zeng, "Design and research on multi-sensory comfort data acquiring of tight sportswear in motion," Journal of Industrial Textiles, vol. 54, Art. no. 15280837241258371, 2024.
[16] P. Cheng, J. Wang, X. Zeng, P. Bruniaux, and D. Chen, "Temperature and Humidity Data Evaluation of Tight Sportswear during Motion Based on Intelligent Modeling," Fibres & Textiles in Eastern Europe, vol. 31, no. 3, pp. 1-8, 2023.
[17] D. P. Born, B. Sperlich, and H. C. Holmberg, "Bringing light into the dark: effects of compression clothing on performance and recovery," International Journal of Sports Physiology and Performance, vol. 8, no. 1, pp. 4-18, 2013.
[18] T. Venckūnas, E. Trinkūnas, S. Kamandulis, J. Poderys, A. Grūnovas, and M. Brazaitis, "Effect of lower body compression garments on hemodynamics in response to running session," The Scientific World Journal, vol. 2014, no. 1, Art. no. 353040, 2014.
[19] F. A. Engel, H. C. Holmberg, and B. Sperlich, "Is there evidence that runners can benefit from wearing compression clothing? Sports Medicine," 2016; 46:1939-1952.

[20] B. A. MacRae, J. D. Cotter, and R. M. Laing, “Compression garments and exercise: garment considerations, physiology and performance,” Sports Medicine, vol. 41, pp. 815-843, 2011.

[21] A. Bringard, S. Perrey, and N. Belluye, “Aerobic energy cost and sensation responses during submaximal running exercise-positive effects of wearing compression tights,” International Journal of Sports Medicine, vol. 27, no. 05, pp. 373-378, 2006.