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Effect Of An Ai-Based Personalised Training Program On Cardiovascular Fitness And Motor Performance In University Students

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Abstract

This research aimed to determine the impact of an AI-based, customized training program on cardiovascular fitness and motor performance. Participants in the study were university students, and hence they were randomly divided into groups: an experimental group (AI-based training; n = 40) and a control group (traditional training; n = 40). The intervention lasted 8 weeks. Cooper Test for VO_2 max, T-test for agility, Stork Stand Test for balance, and Alternate hand wall toss for Coordination were used for data collection. The pre- and posttest results of the study were processed using the statistical package for the social sciences (SPSS, version 26), and thus, parametric statistical tools were applied to the data. On the basis of data analysis, the researcher arrived at the conclusion that personalized training that is developed using AI performs considerably better in cardiovascular fitness and motor performance among university students than traditional training protocols.

Introduction

Artificial intelligence (AI) is technology that enables computers and machines to simulate human learning, understanding, problem solving, decision making, creativity and autonomy. With context sports training, the use of AI is increasing day by day and considered the most reliable and accurate for the improvement of sports performance (Jarrahi, 2018; Bishop et al., 2021; Claudino et al., 2019).

One of the most important health and athletic outcomes is cardiovascular fitness, which can be assessed by the use of the maximal oxygen uptake (VO2max) (Garber et al., 2018). On the same note, motor performance, such as agility, coordination, and balance, are considered to be vital in functional motion and sport competence (Lloyd et al., 2019).

The traditional training programs tend not to be able to implement individuals (sensitivity) and this aspect can restrict their efficacy (Bittencourt et al., 2016). The current developments in the field of artificial intelligence and data-driven training systems have solidified the application of technology in the optimization of sports performance further. AI-driven tools combine machine learning, wearable sensors data, and predictive analytics to customize training interventions, as well as, in real time, track physiological reactions (Baca et al., 2021; Bartlett et al., 2022). These systems have shown great possibilities in enhancing efficiency of training, decision making, and performance levels in elite and recreational athletes.
The current developments in AI have made it possible to create adaptive training systems that change the intensity and volume according to real-time feedback (Rossi et al., 2022). Research work indicates that AI-based interventions have the capability of improving compliance, decreasing the occurrence of injuries and improving performance outcomes (Peake et al., 2019; Wang et al., 2023). Nevertheless, there are few empirical studies targeting the population of universities. The literature review reveals the beneficial relationship between structured physical activities and cardiovascular well-being (Khan et al., 2021) and the increase in aerobic fitness during moderate physical activity (Khan et al., 2022). Also, physical activity initiatives were found to improve motor and general physical fitness of students (Lubans et al., 2010).

METHODS AND MATERIALS

The procedures below were adopted by the researcher to reach certain findings and conclusions.

Study Design

The current study was associated with Effect of an AI-Based Personalized Training Program on Cardiovascular Fitness and Motor Performance in University Students, therefore an experimental research design was applied.

Study Participants

Participants of the study were university students and hence they were randomly divided into groups i.e. experimental group (AI-based training; n = 40) and a control group (traditional training; n = 40). Participants of the study were included by the below criteria
Participants aged 18–25 years were included
Participants who were Healthy, physically active with no chronic disease were included
Participants who voluntarily participant in the study were included

Exercise Intervention

Two different exercise interventions, i.e., traditional with a standardized training protocol (Control group) and AI AI-based exercise intervention (Experimental group), were applied. The duration of exercise was eight (08) with a frequency of 4 sessions/week. The training system is an AI-based solution in which machine learning procedures were applied to adjust the training load based on real-time physiological and performance parameters. The set of inputs included heart rate, movement patterns, and exercise accomplishments measured by wearable sensors. The system used a predictive analytics adaptive model that utilized a rule-based approach to dynamically adjust intensity and volume. Even though a commercial platform was deployed, the adaptive feature was tested based on previous studies of AI-assisted training systems. Cooper Test for VO_2 max, T-test for agility, Stork Stand Test for balance and Alternate hand wall toss for Coordination were used for data collection.

Mode of Application of Exercise Intervention

The researcher personally applied all study protocols to participants. Pre- and posttest results were properly recorded and used in accordance with the study protocol.

Ethical Consideration

Ethical approval was taken from the departmental ethical committee of sports sciences and physical education, university of the Punjab, Lahore, Pakistan. Likewise consent was taken from each and every participant before participation in the study.

Data Analysis

The pre and posttest results of the study were processed through a statistical package for social sciences (SPSS, version-26) and thus suitable statistical tools were applied according to parametric data.

PRESENTATION OF DATA

Table 1. Baseline Characteristics of Participants

Variable	Experimental (n = 40) Mean ± SD	Control (n = 40) Mean ± SD	p-value
Age (years)	21.4 ± 1.8	21.1 ± 1.9	.56
Height (cm)	171.2 ± 6.5	170.8 ± 6.9	.78
Weight (kg)	68.3 ± 8.1	67.9 ± 7.8	.84
VO_2max (ml/kg/min)	38.2 ± 4.1	37.9 ± 3.9	.72
Agility (sec)	11.2 ± 0.8	11.3 ± 0.7	.63
Balance (sec)	28.5 ± 6.2	27.9 ± 5.9	.68
Coordination (score)	18.3 ± 3.5	18.0 ± 3.2	.74

The table shows that all baseline characteristics were similar between the experimental (n = 40) and control (n = 40) groups. Height was 171.2 ± 6.5 vs. 170.8 ± 6.9 cm (p =.78), weight was 68.3 ± 8.1 vs. 67.9 ± 7.8 kg (p =.84), and age was 21.4 ± 1.8 vs. 21.1 ± 1.9 years (p =.56). Similarly, VO_2max was 38.2 ± 4.1 vs. 37.9 ± 3.9 ml/kg/min (p =.72), agility was 11.2 ± 0.8 vs. 11.3 ± 0.7 sec (p =.63), balance was 28.5 ± 6.2 vs. 27.9 ± 5.9 sec (p =.68), and coordination was 18.3 ± 3.5 vs. 3.2 (p =.74). Since every p-value was higher than 0.05, there were no discernible differences and the groups' baseline homogeneity was confirmed.

Table 2. Within-Group Pre–Post Changes (Paired t-test Analysis)

Variable	Group	Pre Mean ± SD	Post Mean ± SD	Mean Difference	t-value	p-value
VO_2max	Experimental	38.2 ± 4.1	45.6 ± 4.8	+7.4	9.12	<.001
VO_2max	Control	37.9 ± 3.9	40.2 ± 4.3	+2.3	2.21	.045
Agility (sec)	Experimental	11.2 ± 0.8	9.8 ± 0.7	−1.4	7.45	<.001
Agility	Control	11.3 ± 0.7	10.9 ± 0.6	−0.4	1.89	.08
Balance (sec)	Experimental	28.5 ± 6.2	36.8 ± 7.1	+8.3	6.12	<.001
Balance	Control	27.9 ± 5.9	30.1 ± 6.3	+2.2	2.03	.049
Coordination	Experimental	18.3 ± 3.5	24.7 ± 3.9	+6.4	8.01	<.001

Variable	Group	Pre Mean ± SD	Post Mean ± SD	Mean Difference	t-value	p-value
Coordination	Control	18.0 ± 3.2	20.1 ± 3.4	+2.1	2.15	.038

The table compares the experimental and control groups' VO_2max, agility, balance, and coordination before and after the test. VO_2max increased from 38.2 ± 4.1 to 45.6 ± 4.8 (Δ = +7.4, p <.001), agility improved from 11.2 ± 0.8 to 9.8 ± 0.7 sec (Δ = −1.4, p <.001), balance improved from 28.5 ± 6.2 to 36.8 ± 7.1 sec (Δ = +8.3, p <.001), and coordination improved from 18.3 3.5 to 24.7 ± 3.9 (Δ = +6.4, p <.001).
The control group, on the other hand, showed less improvement. VO_2max rose marginally from 37.9 ± 3.9 to 40.2 ± 4.3 (Δ = +2.3, p =.045), balance from 27.9 ± 5.9 to 30.1 ± 6.3 (Δ = +2.2, p =.049), and coordination from 18.0 ± 3.2 to 20.1 ± 3.4 (Δ = +2.1, p =.038). Nevertheless, there was no statistically significant improvement in agility (11.3 ± 0.7 to 10.9 ± 0.6, Δ = −0.4) (p =.08). Overall, the experimental group improved significantly more than the control group, demonstrating the intervention's high efficacy.

Table 3. Between-Group Comparison of Post-Test Scores (Independent t-test)

Variable	Experimental Mean ± SD	Control Mean ± SD	Mean Difference	t-value	p-value
VO_2max	45.6 ± 4.8	40.2 ± 4.3	5.4	5.21	<.001
Agility (sec)	9.8 ± 0.7	10.9 ± 0.6	−1.1	6.34	<.001
Balance (sec)	36.8 ± 7.1	30.1 ± 6.3	6.7	4.29	<.001
Coordination	24.7 ± 3.9	20.1 ± 3.4	4.6	5.03	<.001

The table demonstrates that there were statistically significant differences (p <.001) between the experimental and control groups in every post-test variable. There were improvements in VO_2max (45.6 ± 4.8 vs. 40.2 ± 4.3; Δ = 5.4), agility (9.8 ± 0.7 vs. 10.9 ± 0.6; Δ = −1.1), balance (36.8 ± 7.1 vs. 30.1 ± 6.3; Δ = 6.7), and coordination (24.7 ± 3.9 vs. 20.1 3.4; Δ = 4.6). These findings show that the experimental group was clearly superior.

RESULT & DISCUSSION

The current research explored the theory of an AI-based custom training program and its impact on cardiovascular fitness and motor performance among university students similarly the result of the current study reveals that personalized training that is developed using AI performs considerably better in cardiovascular fitness and motor performance among university students than the traditional training protocols. Such emerging concept is supported by Claudino et al., (2019) by stating that that AI-based training is adaptive and adjusts the intensity of exercise in real-time using physiological feedbacks. Theoretically, such dynamism changes can maximize the relationships between training stimulus and recovery which can be considered the main idea of adaptive training theory (Claudino et al., 2019). In contrast, Past studies have indicated that personalized exercise instructions prove more effective than generalized programs concerning the enhancement of cardiopulmonary volume (Bishop et al., 2021), and the current results only confirm the previous data in a university sample. On the same note, drastic changes in motor performance parameters- especially agility and coordination- indicate the importance of AI in the process of improving the neuromuscular efficiency. According to motor learning theory, change in practice and prompt feedback is a crucial factor in skills acquisition (Lloyd et al., 2019). Most of these processes could easily be mediated by the AI system applied in the current study, as it offered instant corrections and also through the incremental increase in the task difficulty. This corresponds to the results of the recent research that confirmed that technology-assisted training improves precision of movements and reaction time (Wang et al., 2023). The slight decrease in the effect size of balance showed statistically and practically significant balance improvements. This could be explained by the fact that the proprioceptive and the stabilization exercises are also part of the AI program and are known to enhance the postural control (Rossi et al., 2022). A smaller effect size of balance might also be due to the more time required in most cases to have neuromuscular adaptations relative to postural stability.

These findings are in accordance with previous literature that has pointed at the usefulness of structured exercise interventions as far as cardiovascular health is concerned. As an illustration, Aamir Khan and Muhammad Zafar Iqbal Butt (2021) found that regular activity led to a dramatic repeat of cardiovascular efficiency, whereas subsequent research by them (2022) found out improvements of aerobic fitness in a specific exercise plan. Nonetheless, the present research builds on such understanding by showing that AI-driven personalization leads to much more notable benefits as compared to traditional approaches. Similar to Joao Guilherme Claudino et al. (2019), the given research proves that AI-based applications have the ability to streamline the training load and enhance the performance results.

On the same note, the results are consistent with the works of Aaron Rossi et al. (2022), who underlined the importance of AI in optimization of training and injury prevention. These gains in motor performance are also related to the findings of Rhys Lloyd et al. (2019) who emphasized the role of organized, gradual training during motor skill development. Nevertheless, the induced improvement in the current research is greater than the ones reported in conventional training papers, which hints that AI-based systems can speed up the learning of motor processes. Moreover, the results align with the recent development of machine learning application in the exercise science by Liang Wang et al. (2023), who found that AI-based interventions improve performance and adherence. As the involvement and motivation heightened during AI-based training, this could have led to the higher results in the experimental group as per the self-determination theory.

CONCLUSION

On the basis of data analysis and findings, the researcher concluded that personalized training involving the use of AI is very effective in enhancing cardiovascular fitness and motor performance among students at universities. The research is applicable to the developing body of evidence on the use of technology-based training interventions and a basis on which future studies may be conducted.

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