ORIGINAL ARTICLE

The AI coach: A 5-week AI-generated calisthenics training program on health-related physical fitness components of untrained collegiate students

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ABSTRACT

The study aims to investigate the effect of a 5-week artificial intelligence-generated calisthenics training program (AIGCTP) on health-related physical fitness components, including flexibility, cardiovascular endurance, and muscular endurance. Utilizing a quasi-experimental design, the study employed a one-group pre-test-post-test design for within-group comparisons and a two-group pre-test-post-test design for between-group comparisons. Participants included 87 untrained collegiate students, divided into the AIGCTP group (43 participants) and a human-made calisthenics training program (HMCTP) group (44 participants), selected via purposive sampling. A paired t-test was used for within-group comparisons, and an independent sample t-test was used for between-group comparisons. The findings indicated that the AIGCTP effectively improved the flexibility of the lower extremities and the muscular endurance of the core and upper extremities. However, female participants did not show significant improvements in any health-related physical fitness components, whereas male participants demonstrated improvements in the flexibility of the lower extremities and muscular endurance of the upper extremities. The HMCTP was effective in improving the flexibility and muscular endurance of the lower and upper extremities for all participants. Between-group comparisons revealed that the cardiovascular endurance of the HMCTP group was significantly superior to that of the AIGCTP group, irrespective of sex. Additionally, males in the HMCTP group exhibited significantly higher muscular endurance of the lower extremities compared to those in the AIGCTP group. The study suggests that AI can be used for fitness training, but professional-made programs are superior in some areas. Future research should replicate these findings, examine more fitness components, and explore longer training durations for further validation.

Keywords: Physical education, Muscular endurance, Flexibility, Cardiovascular, Artificial intelligence, Calisthenics.

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INTRODUCTION

Artificial intelligence is the science and engineering concerning developing systems that display human characteristics and behaviour (Tecuci, 2012). It mimics the human level of intelligence, such as logical reasoning, learning, and problem-solving (Morandín-Ahuerma, 2022). It is widely in the field of medicine (Yu et al., 2018; Lopez-Jimenz et al., 2020; Hamet & Tremblay, 2017; Zhuo et al., 2020; Xu et al.,2021), human biology (Hamet & Temblay, 2017), nutrition (Sak & Suchodolska, 2021), and education (Chen et al., 2020; Zawacki-Richter et al., 2019; Boulay, 2016; Zafari et al., 2022). Not only in rigid disciplines, but it also thoroughly used in social life and economic activities which contributes to solving various social problems through robotic technologies (Lu et al., 2017). It can even complete tasks that require empathy (Huang & Rust, 2018). Despite numerous uses of artificial intelligence, it has limitations on things it can perform based on the information that is fed to it (Wang, 2019). It has even been capable of extincting human jobs (Huang & Rust, 2018). while artificial intelligence exhibits remarkable capabilities across various fields, including medicine, human biology, nutrition, education, and social problem-solving, its potential limitations and impact on human employment must be carefully considered and managed.

Physical fitness is defined as the capability of an individual to perform daily tasks with vigour (Pate, 1988). It is completed by different components, which are divided into two, health-related and Skill-related physical fitness components (Wilder et al., 2006; Caspersen et al., 1985). Health-related physical fitness components are heavily influencing an individual's health (McKelphin, 2015). On the other hand, skill-related physical fitness components refer to parameters that are essential for motor skills and movement pattern execution (deMet & Wahl-Alexander, 2019). For the purpose of this study, health-related physical fitness components such as cardiovascular endurance, muscular endurance, and flexibility were focused on. Enhanced cardiovascular endurance is linked with better high health status, such as increased integrity of cerebral white matter (Johnson et al., 2012), lowered risk of high blood pressure (Sui et al., 2017), higher capability to execute different activities (Wong et al., 2015), and a chance of reduced coronary heart disease and mortality (Gander et al., 2015). The low level of this component causes many health-related issues. Low cardiovascular fitness correlates with higher body mass index and increased waist circumference, elevating susceptibility to cardiovascular disease (Berge et al., 2019; Carbone et al., 2020). It also correlates with psychological distress and is established as a predictor of psychological health (Zeiher et al., 2019). High cardiovascular fitness is associated with increased mental toughness, particularly among athletes (Latif et al., 2022). Muscular endurance, vital for fitness (Robert & Hockey, 1973), predicts lower BMI (Ding & Jiang, 2020; Garcia-Hermoso et al., 2019), reduces obesity risk, and is linked to lower all-cause mortality and cardiovascular disease risk (Corder et al., 2019), emphasizing its role in weight management and disease prevention. Despite its health significance, it is essential to know the possible effects of having a low level of this component. Low muscular endurance adversely affects athletic performance, increases injury risk, and correlates with cardiovascular diseases and metabolic factors (Ambegankar et al., 2012; Artero et al., 2012; Walker et al., 2017). It also impacts psychological well-being, increasing susceptibility to anxiety and psychiatric conditions (Ganasarajah et al., 2019; Ortega et al., 2012). Premature mortality, especially through an elevated risk of suicide before the age of 55, further underscores the implications of low muscular endurance (Ortega et al., 2012). Flexibility, crucial for physical well-being, is particularly important in athletics, positively influencing essential fitness components such as muscle power and strength (Arntz et al., 2023). Poor trunk flexibility is linked to arterial stiffness, affecting athletic performance and causing lower back pain in elite divers (Carrol & Mock, 2023; Šrimpf et al., 2019). Therefore, maintaining and enhancing health-related physical fitness components such as cardiovascular endurance, muscular endurance, and flexibility is crucial for overall health, disease prevention, and both physical and psychological well-being.

Artificial intelligence exercise prescription refers to the application that uses artificial intelligence to generate a training program based on the prompt given to the application. Meanwhile, Artificial intelligence-generated training programs were rising in the discipline of fitness. Artificial intelligence was used in assistance through recommendations based on neural networks and logistic regression based on its user (Tran et al., 2018; Ijsrem journal, 2023) through evolutionary computation and swarm intelligence (Fister, 2017). Its training program output was suggested to be an effective way to improve leg power, agility, vertical pulling movements, and squat movement (Du, 2021). Also, it can generate high-specificity training programs, which improves physical fitness (Wang & Park, 2021). It can also substitute for opponents by mimicking fundamental athlete movements, enhancing the quality of training sessions (Lei, 2023). Also, it can even provide feedback on the movement patterns of the exercisers during weight training. (Novatchkov and Baca, 2013). It was found that AI-generated training programs from ChatGPT 3.5 and ChatGPT 4.0 were objectively the same regardless of sex and could be effectively used for training purposes with human intervention (Washif et al., 2024). However, it was also argued that the usage of AI in exercise prescription served as supplemental tools (Cheng et al.,2023) and cannot substitute for personalized progressive and health condition-specific training programs provided by health care and fitness professionals (Zaleski et al., 2024). With this, several studies developed AI-generated systems that assist professionals in work, such as exercise prescriptions for therapy (Ishraque et al., 2018; Pharbu et al., 2020). While AI-generated training programs offer effective and efficient fitness solutions with benefits such as improving physical fitness and mimicking natural athlete movements, They should be viewed as supplemental tools to support, rather than replace, personalized training provided by healthcare and fitness professionals.

The literature about artificial intelligence on fitness was diverse. However, it needs to include careful investigation of Artificial intelligence-generated training programs and their effect on physical fitness. Also, it is essential to compare the trend of the traditional training program that humans created. With this, individuals will have an idea and caution about using AI on their fitness journey. Lastly, It was suggested that the impact of Artificial intelligence on fitness should be furthered explored (Prashar et al., 2023), and its validity and reliability should be put in rigor checking (Saadati. 2023). The study aims to investigate the effect of a 5-week Artificial intelligence-generate Calisthenics training program on health-related physical fitness components such as flexibility, cardiovascular endurance, and muscular endurance. Specifically, it also investigated the effect of an adopted calisthenic training program. A comparative analysis was done between artificial intelligence-generated and adopted calisthenic training programs regarding their effectivity on improving the aforementioned physical fitness components. Lastly, it has a sex-specific approach to its investigation between the independent variables and dependent variables.

METHODOLOGY

Research design

The study utilized a quasi-experimental design. Specifically, it used one group pre-test-post-test design on the within-group comparison. As for the between-group comparison, a two-group pre-test-post-test design was utilized. The experimental design was implemented to fully understand the causal relationship between the independent variables (Human-made and Artificial Intelligence training programs) and dependent variables (Selected health-related physical fitness components).

Sampling and participants

The study's participants were 87 untrained collegiate students who were selected using a purposive sampling method. The inclusion criteria were set, which are (1) a bonafide student of the locale of the study, (2) no formal or habitual training, and (3) no medical issues that can be worsened or triggered by moderate to vigorous activity. Table 1 shows the distribution of the participants based on group and sex. Artificial Intelligence-generated calisthenics training program group (AIGCTP) was the group who were administered by the 5-week Artificial Intelligence-generated calisthenics training program. The said training program was generated using ChatGPT 3.5. The group comprises 24 females, who comprise 27.59% of the participants. 19 male participants completed the 21.84 %. In totality, the group consists of 49.43% of the AIGCTP group. The Human-made calisthenics training program group (HMTCP) was administered by an adopted calisthenics training program from a study. The group had the remaining 50.57% of the participants, composed of 44 members. Female participants comprised 20, which is 22.99% of the participants. As for male participants, they consist of 49.43%. The HMCTP group comprises 50.57% of the participants by having 44 participants. The study had 87 participants.

Table 1. Distribution of sex of the participants per group.

	Female	Male	Total
AIGCTP	24(27.59%)	19(21.84%)	43(49.43%)
HMCTP	20(22.99%)	24(27.59%)	44(50.57%)
Total	44(50.57%)	43(49.43%)	87(100%)

Table 2 shows the body composition of both groups. The AIGCTP group had a mean height of 164.97 ± 7.61 cm and a mean weight of 61.91 ± 10.70 kg. In totality, the body mass index of the group was 22.79 ± 3.90. On the other hand, the HMTCP group had a mean height of 164.97 ± 7.61 cm and a mean weight of 64.63 ± 11.88 kg. This constitutes the mean body mass index of 23.91 ± 4.24. Despite the groupings, the participants had a mean height of 164.74 ± 7.31 and a mean weight of 63.28 ± 11.33, contributing to the mean body mass index of 23.36 ± 4.09.

Table 2. Distribution of the body composition of the participants per group.

	AIGCTP	HMCTP	Total
Height	164.97 ± 7.61	164.51 ± 7.08	164.74 ± 7.31
Weight	61.91 ± 10.70	64.63 ± 11.88	63.28 ± 11.33
BMI	22.79 ± 3.90	23.91 ± 4.24	23.36 ± 4.09

Instruments

Several validated and reliable field tests were utilized to quantify the selected health-related physical fitness components used as dependent variables in the study. First, the Sit and Reach Test was used. It is recognized as a valid and reliable field test for measuring the flexibility of the hamstrings and lower back (Amiri-Khorasani et al., 2017). To perform the Sit and Reach Test, tape a measuring stick to the floor with a 24-inch piece of tape at the 15-inch mark, and have the participant warm up with non-ballistic hamstring and lower back exercises. Sitting barefooted with legs extended and feet 12 inches apart, the athlete should slowly reach forward along the measuring stick, exhaling and dropping their head between their arms while keeping hands together and knees extended. The best of three trials is recorded to the nearest 0.25 inches or 1 cm, with scores below 15 inches indicating the athlete could not reach their feet. Secondly, a field test that measures cardiovascular endurance was used; the Three-Minute Step Test is recognized as a validated and reliable test for cardiovascular endurance, having been utilized across different age groups (Petric et al., 2017). A step height of 12 inches (30.5 cm) is used to administer this test. Participants are instructed to step up and down on the platform at a rate of 96 beats per minute for three minutes. Immediately after the three minutes, participants sit down and measure their heart rates for one full minute. The heart rate is then recorded. Thirdly, the Wall sit test was used to quantify the muscular endurance of the lower extremities. It is recognized as a reliable field test for assessing lower-body muscular endurance among children (Boyer et al., 2013). To perform this test, the participant should stand with their back against a wall, with feet positioned shoulder-width apart. The participant then slowly slides down the wall until their knees are at a 90-degree angle. This position is held for as long as possible, and the time the position is maintained is recorded. The fourth field test is the Plank Test, a well-supported by numerous studies as a reliable and valid method for assessing core muscle endurance in children and older adults (Bohannon et al., 2017) and youth (Laurson et al., 2022) was utilized in quantifying muscular endurance of the core. To administer this test, the participant begins in a prone position, supporting their weight on their toes and forearms. The body must be kept in a straight line from head to ankles. The participant holds this position for as long as possible, with the duration of time maintained being recorded. Lastly, the muscular endurance of the upper extremities was measured through a One-minute Push-up test. The test is recognized for its robust inter-rater and intra-rater reliability. It confirms its usage as a reliable field test for measuring upper extremity muscular endurance (Fielitz et al., 2016). To perform this test, the participant starts in a plank position with arms straight and hands placed shoulder-width apart. The participant then lowers their body until the chest nearly touches the floor, then pushes back up to the starting position. This cycle is repeated as many times as possible within one minute, and the total number of push-ups completed is recorded. This protocol effectively assesses the muscular endurance of the upper extremities.

Data gathering procedure

Adherence to the training programs

The participants underwent a thorough discussion of the training program. This involves the explanation and demonstration of each exercise incorporated in the programs. Also, guidelines, which include the specification of the training, such as preparatory exercises, instruction on the execution of exercises, and cooldown exercises, were given to the participants. Lastly, the participants were also told to strictly adhere to the training program by refraining from other forms of exercise for ten weeks. Protocols were done to minimize possible threats to internal validity.

Sequence of the field test administration

The study instruments were administered to the participants with a strategic pattern to prevent compounding effects on subsequent tests. Initially, a whole-body warm-up and dynamic stretching were implemented to prepare the participants' bodies. The Sit and Reach Test was administered first, as it was considered a non-fatiguing test. This was followed by muscular endurance testing. The study included three muscular endurance tests: the one-minute push-up test, the plank test, and the wall sit test. These tests were performed with an hour of recovery between each to ensure that the participants' phosphagen (Bognadis et al., 1995; Dawson et al., 1997) and anaerobic glycolytic (Buchheit & Laursen, 2013) energy systems were fully recovered. This recovery period also ensured that subsequent muscular endurance tests were free from the compounding effects of the prior tests. After the muscular endurance tests, the cardiovascular endurance test, a three-minute step test, was administered to the participants.

Pre-testing

The participants underwent the respective field tests for the selected health-related physical fitness components, following the sequence of tests meticulously.

Implementation of the training programs

A day after the pre-testing, the implementation of the respective training programs per group commenced. The AIGTCP group was administered by the 5-week artificial intelligence-generated Calisthenics training program, which was created using ChatGPT 3.5. The prompt includes the specifics of the training program using the principles of frequency, intensity, time, and type. Below is the exact prompt inputted in the ChatGPT 3.5.

Prompt: Please create a 5-week calisthenics training program with three times sessions per week. Each session should last for 60-90 minutes. The intensity should be tailored for untrained collegiate students.

Using this prompt, a training program was created. Below is the tabular version of the 5-week AI-generated Calisthenics program for untrained collegiate students.

Table 3. 5-week artificial intelligence-generated calisthenics training program.

Weekly schedule	**Session duration**	**Workout structure**
• Three times a week (e.g., Monday, Wednesday, Friday)	• 60 to 90 minutes each. • Each session is divided into a Warm-up, Main Workout, and Cool-down phase.	• Intensity: Exercises are performed at a moderate pace where students can complete all repetitions with good form but feel challenged by the last two reps of each set.
Warm-Up (15 minutes)		**Main workout (40-65 minutes)**
• 5 minutes of light cardiovascular exercise (jogging, jumping jacks). • 10 minutes dynamic stretches (arm circles, leg swings, lunges).		• Intensity: Exercises are performed at a moderate pace where students can complete all repetitions with good form but feel challenged by the last two reps of each set.
Circuit 1: Upper body & core (repeat circuit 3 times)	**Circuit 2: Lower body & agility (repeat circuit 3 times)**	**Circuit 3: Core & balance (repeat circuit 3 times)**
• Push-Ups - 3 sets of 8-12 reps. • Dips (using a bench) - 3 sets of 8-10 reps. • Plank - 3 sets of 30-45 seconds.	• Bodyweight Squats - 3 sets of 12-15 reps. • Lunges - 3 sets of 10 reps per leg. • Box Jumps (or step-ups if no box available) - 3 sets of 8-10 reps.	• Leg Raises - 3 sets of 10-12 reps. • Russian Twists - 3 sets of 15 reps per side. • Bird-Dog (alternating arms and legs) - 3 sets of 10 reps per side.
Cool-Down (10-15 minutes)		
• 5 minutes of slow walking or gentle jogging to bring the heart rate down. • 5-10 minutes of static stretching focusing on all major muscle groups.		
Notes on progression and intensity		
• Progression: Increase the number of reps or sets every two weeks by 10-20% as fitness improves.	• Intensity Adjustments: If the workouts become too easy, variations can be introduced to increase the difficulty, such as elevating feet for push-ups or adding a light backpack for squats and lunges.	• Rest Between Circuits: Aim for 1-2 minutes of rest between circuits to maintain a good workout pace without leading to excessive fatigue.

On the other hand, the human-made calisthenics training program was made by adopting a calisthenics training program of a study. Originally, the training program was designed for 10 weeks. For the purpose of similarity of training duration, it was compressed into 5 weeks. The HMCTP group participated in a 5-week whole-body calisthenic program involving three sessions per week (Masagca, 2024). Each session comprised six exercises targeting the upper and lower body and the core. The training program progressed by introducing progressively more kinetically demanding exercises. In each session, the participants were asked to do warm-ups and dynamic stretching as preparatory exercises. To conclude the session, cooldown exercises in the form of static stretching. The adopted 5-week whole-body calisthenic program is outlined in the Table 4.

Table 4. 5-week human-made calisthenics training program.

Training Program A (Week 1-2)		
Upper body	**Core**	**Lower body**
Wall push up	Dead bug position	Kneeling hip hinge
Chair push up	Straight leg Lift raise	Standing double leg hip hinge
Training Program B (Week 3-4)		
Negative Knee Push up	Dead bug with hip, knee, and shoulder extension (Same side)	Chair Squat
Knee pushes up	Leg raises	Squat with a chair as assistance
Training Program C (Week 5)		
Negative Push-ups	Dead bug with hip, knee, and shoulder extension (Contralateral)	Body weight squats
Push-ups	Isometric hold leg raises	Hinge Squat

Post testing

The participants underwent the same field-testing protocol after 48 to 72 hours of recovery. This recovery period was set in order to minimize the effect of the last training sessions on the components that need to be measured (Goulart et al., 2020; Robineau et al., 2016).

Data analysis

The study utilized a paired t-test for the within-group comparison of each calisthenics training program on the selected health-related physical fitness components. As for the between-group comparison, an independent sample t-test was used. The significance level was set to $p < .05$ for discrepancies to be categorized as significant.

Potential ethical issues

The participants were given a comprehensive briefing on the study, which included a discussion about their rights within the study context. Afterwards, individuals were asked to provide informed consent by completing a consent letter. Subsequently, a Physical Readiness Questionnaire was administered to ascertain the presence of any concealed medical conditions among the subjects. To conclude, it is essential to emphasize that the acquired data was handled with utmost confidentiality and disclosed to the owner upon their request.

RESULTS

The AIGCTP Group underwent various physical fitness tests for flexibility, muscular endurance, and cardiovascular endurance before and after the administration of the artificial intelligence-generated 5-week calisthenics training program. Table 5 shows the pre-test and post-test data for the AIGTCP Group. Also, it has sex-specific within-group comparisons. Despite sex, the flexibility of the lower extremities was significantly increased ($SART^{Pretest} = 46.43 \pm 8.83$, $SART^{Posttest} = 53.80 \pm 21.94$, $t = 2.82$, $p < .05$). This was also the case for the muscular endurance of the upper extremities ($OMPUT^{Pretest} = 15.86 \pm 9.77$, OMPUT^{Posttest} = 22.48 ± 12.36, t = 3.45, *p* < .05). contradictorily. The muscular endurance of the core was found to be significantly increased by the said training program (PT^{Pretest} = 76.44 ± 36.88, PT^{Posttest} = 64.57 ± 41.76, t = 2.13, *p* < .05). The cardiovascular endurance (3MST^{Pretest} = 146.26 ± 24.02, 3MST^{Posttest} = 154.98 ± 80.35, t = 0.74, *p* = .46) and muscular endurance of the lower extremities (WST^{Pretest} = 51.40 ± 35.59, WST ^{Posttest} = 51.19 ± 36.15, t = -0.07, *p* = .95) were insignificantly changed by the administration of the training program. For female participants, insignificant changes were observed throughout all of the health-related physical fitness components such as flexibility of the lower extremities (SART^{Pretest} = 46.16 ± 8.99, SART^{Posttest} = 54.68 ± 28.18, t = 1.88, *p* = .07), cardiovascular endurance (3MST^{Pretest} = 146.52 ± 25.83, 3MST^{Posttest}= 160.68 ± 77.38, t = 1.01, *p* = .32), and muscular endurance of the lower extremities (WST^{Pretest} = 49.26 ± 26.99, WST^{Posttest} = 49.14 ± 25.14, t = -0.03, *p* = .97), core (PT^{Pretest} = 68.01 ± 31.33, PT^{Posttest} = 54.28 ± 35.86, t = -1.72, *p* = .10), and upper extremities (OMPUT^{Pretest} = 12.29 ± 6.13, OMPUT^{Posttest} = 14.76 ± 5.21, t = 1.95, *p* = 0.06). Finally, it was seen that the male participants' lower limb flexibility (SART^{Pretest} = 46.79 ± 8.85, SART^{Posttest} = 52.63 ± 9.68, t = 4.73, *p* < .05) and upper limb muscular endurance (OMPUT^{Pretest} = 20.61 ± 11.74, OMPUT^{Posttest} = 32.63 ± 11.72, t = 3.15, *p* < .05) were both significantly higher. However, insignificant changes were suggested for cardiovascular endurance (3MST^{Pretest} = 145.89 ± 21.98, 3MST^{Posttest} = 147.47 ± 85.64, t = 0.07, *p* = .94), muscular endurance of the lower extremities (WST^{Pretest} = 54.21 ± 45.17, WST^{Posttest} = 53.89 ± 47.60, t = -0.06, *p* = .95) and the core (PT^{Pretest} = 87.53 ± 41.37, PT^{Posttest} = 78.11 ± 45.45, t = -1.22, *p* = .24).

Table 5. Pre and Post-test of the AIGCTP Group.

	Pre-test	**Post-test**	***t*-value**	***p*-value**
All				
SART	46.43 ± 8.83	53.80 ± 21.94	2.82	<.05
3MST	146.26 ± 24.02	154.98 ± 80.35	0.74	.46
WST	51.40 ± 35.59	51.119 ± 36.15	-0.07	.95
PT	76.44 ± 36.88	77.57 ± 41.76	2.13	<.05
OMPUT	15.86 ± 9.77	22.48 ± 12.36	3.45	<.05
Female				
SART	46.16 ± 8.99	54.68 ± 28.18	1.88	.07
3MST	146.52 ± 25.83	160.68 ± 77.38	1.01	.32
WST	49.26 ± 26.99	49.14 ± 25.14	-0.03	.97
PT	68.01 ± 31.33	54.28 ± 35.86	-1.72	.10
OMPUT	12.29 ± 6.13	14.76 ± 5.21	1.95	.06
Male				
SART	46.79 ± 8.85	52.63 ± 9.68	4.73	<.05
3MST	145.89 ± 21.98	147.47 ± 85.64	0.07	.94
WST	54.21 ± 45.17	53.89 ± 47.60	-0.06	.95
PT	87.53 ± 41.37	78.11 ± 45.45	-1.22	.24
OMPUT	20.61 ± 11.74	32.63 ± 11.72	3.15	<.05

The HGCTP Group underwent various physical fitness tests for flexibility, muscular endurance, and cardiovascular endurance before and after the administration of the adopted calisthenics program (Masagca, 2024) for 5 weeks. Table 6 shows the pre-test and post-test data for the HGCTP Group. Despite sex, the flexibility of the lower extremities was significantly increased (SART^{Pretest} = 45.12 ± 9.62, SART^{Posttest} = 50.30 ± 10.33, t = 3.87, *p* < .05). This was also the case for the muscular endurance of the upper extremities (OMPUT^{Pretest} = 19.81 ± 8.30, OMPUT^{Posttest} = 24.72 ± 10.91, t = 2.81, *p* < .05) and the muscular endurance of the lower extremities (WST^{Pretest} = 52.71 ± 23.44, WST^{Posttest} = 74.78 ± 69.04, t = 2.65, *p* < .05). The cardiovascular endurance ($3MST^{Pretest}$ = 115.07 ± 35.70, $3MST^{Posttest}$ = 105.40 ± 24.94, t = -1.93, p = .06) and muscular endurance of the core ($PT^{Pretest}$ = 88.43 ± 65.85, $PT^{Posttest}$ = 77.88 ± 57.84, t = -1.51, p = .14) were insignificantly changed by the administration of the training program. For female participants, insignificant changes were observed throughout all of the health-related physical fitness components such as flexibility of the lower extremities ($SART^{Pretest}$ = 44.68 ± 8.60, $SART^{Posttes}$t = 47.24 ± 7.91, t = 1.77, p = .09), cardiovascular endurance (3MSTPretest = 110.63 ± 35.35, 3MSTPosttest = 106.44 ± 28.02, t = -0.11, p = .91), muscular endurance of the lower extremities ($WST^{Pretest}$ = 52.38 ± 17.40, $WST^{Posttest}$ = 59.08 ± 18.42, t = 1.29, p = .21), core ($PT^{Pretest}$ = 71.68 ± 27.43, $PT^{Posttest}$ = 65.47 ± 25.50, t = -1.16, p = .26), and upper extremities ($OMPUT^{Pretest}$ = 16.42 ± 7.13, $OMPUT^{Posttest}$ = 16.84 ± 6.34, t = 0.24, p = .81). Finally, it was seen that the male participants' lower limb flexibility ($SART^{Pretest}$ = 45.46 ± 10.53, $SART^{Posttest}$ = 52.77 ± 11.47, t = 3.53, p < .05), cardiovascular endurance ($3MST^{Pretest}$ = 120.83 ± 33.18, $3MST^{Posttest}$ = 104.63 ± 22.96, t = -3.94, p < .05), upper limb muscular endurance ($OMPUT^{Pretest}$ = 22.50 ± 8.30, $OMPUT^{Posttest}$ = 30.96 ± 9.71, t = 3.21, p < .05), and lower limb muscular endurance ($WST^{Pretest}$ = 52.98 ± 27.68, $WST^{Posttest}$ = 87.21 ± 89.85, t = 2.43, p < .05) were all significantly higher. However, insignificant changes were suggested for the muscular endurance of the core ($PT^{Pretest}$ = 101.69 ± 83.15, $PT^{Posttest}$ = 87.81 ± 73.29, t = -0.24, p = 1.17).

Table 6. Pre and Post-test of the HGCTP Group.

	Pre-test	Post-test	*t*-value	*p*-value
All				
SART	45.12 ± 9.62	50.30 ± 10.33	3.87	<.05
3MST	115.07 ± 35.70	105.40 ± 24.94	-1.93	.06
WST	52.71 ± 23.44	74.78 ± 69.04	2.65	<.05
PT	88.43 ± 65.85	77.88 ± 57.84	-1.51	.14
OMPUT	19.81 ± 8.30	24.72 ± 10.91	2.81	<.05
Female				
SART	44.68 ± 8.60	47.24 ± 7.91	1.77	.09
3MST	110.63 ± 35.35	106.44 ± 28.02	-0.11	.91
WST	52.38 ± 17.40	59.08 ± 18.42	1.29	.21
PT	71.68 ± 27.43	65.47 ± 25.50	-1.16	.26
OMPUT	16.42 ± 7.13	16.84 ± 6.34	0.24	.81
Male				
SART	45.46 ± 10.53	52.77 ± 11.47	3.53	<.05
3MST	120.83 ± 33.18	104.63 ± 22.96	-3.94	<.05
WST	52.98 ± 27.68	87.21 ± 89.85	2.43	<.05
PT	101.69 ± 83.15	87.81 ± 73.29	-0.24	1.17
OMPUT	22.50 ± 8.30	30.96 ± 9.71	3.21	<.05

Table 7 shows the comparison between AIGTCP and HGTCP on the selected health-related physical fitness components. Despite sex, among all of the components, only the cardiovascular endurance was found to be significantly different between the two groups ($3MST^{AIGTCP}$ = 154.98 ± 80.35, $3MST^{HGTCP}$ = 105.40 ± 24.94, t = 3.82, p < .05). However, the flexibility of the lower extremities ($SART^{AIGTCP}$ = 53.80 ± 21.94, $SART^{HGTCP}$ = 50.30 ± 10.33, t = 0.94, p = .97), and muscular endurance of lower extremities (WST^{AIGTCP} = 51.19 ± 36.15, WST^{HGTCP} = 74.78 ± 69.04, t = 2.00, p = .15), core(PT^{AIGTCP} = 64.57 ± 41.76, PT^{HGTCP} = 77.88 ± 57.84, t = 1.23, p = .62), and upper extremities($OMPUT^{AIGTCP}$ = 22.48 ± 12.36, $OMPUT^{HGTCP}$ = 24.72 ± 10.91, t = 0.90, p = .61) were found to be insignificantly different between each group. For female participants, only the cardiovascular endurance was significantly different between the two groups ($3MST^{AIGTCP}$ = 160.68 ± 77.38, 3MST^{HGTCP} = 106.44 ± 28.02, t = 0.01, *p* < .05). Contradictorily, Flexibility of the lower extremities (SART^{AIGTCP} = 54.68 ± 28.18, SART^{HGTCP} = 47.24 ± 7.91, t = 0.27, *p* = .27), muscular endurance of lower extremities (WST^{AIGTCP} = 49.14 ± 25.14, WST^{HGTCP} = 59.08 ± 18.42, t = 0.15, *p* = .15), core (PT^{AIGTCP} = 54.28 ± 35.86, PT^{HGTCP} = 65.47 ± 25.50, t = 0.25, *p* = .25), and upper extremities (OMPUT^{AIGTCP} = 14.76 ± 5.21, OMPUT^{HGTCP} = 16.84 ± 6.34, t = 0.24, *p* = .24) were insignificantly different between the two group. For male participants, cardiovascular endurance and muscular endurance of lower extremities were significantly different between the two groups. The cardiovascular endurance (3MST^{AIGTCP} = 147.47 ± 85.64, 3MST^{HGTCP} = 104.63 ± 22.96, t = 0.02, *p* < .05) and muscular endurance of lower extremities (WST^{AIGTCP} = 53.89 ± 47.60, WST^{HGTCP} = 87.21 ± 89.85, t = 0.15, *p* < .05) showed significant differences. Flexibility of the lower extremities (SART^{AIGTCP} = 52.63 ± 9.68, SART^{HGTCP} = 52.77 ± 11.47, t = 0.97, *p* = .35), muscular endurance of the core (PT^{AIGTCP}=78.11 ± 45.45, PT^{HGTCP} = 87.81 ± 73.29, t = 0.62, *p* = .22), and upper extremities (OMPUT^{AIGTCP} = 32.63 ± 11.72, OMPUT^{HGTCP} = 30.96 ± 9.71, t = 0.61, *p* = .37) were insignificantly different between each group.

Table 7. Post-test data comparison between AIGTCP Group vs HGCTP Group

	AIGTCP	**HGCTP**	***t*-value**	***p*-value**
All				
SART	53.80 ± 21.94	50.30 ± 10.33	0.94	.97
3MST	154.98 ± 80.35	105.40 ± 24.94	3.82	<.05
WST	51.119 ± 36.15	74.78 ± 69.04	2.00	.15
PT	77.57 ± 41.76	77.88 ± 57.84	1.23	.62
OMPUT	22.48 ± 12.36	24.72 ± 10.91	0.90	.61
Female				
SART	54.68 ± 28.18	47.24 ± 7.91	0.27	.27
3MST	160.68 ± 77.38	106.44 ± 28.02	0.01	<.05
WST	49.14 ± 25.14	59.08 ± 18.42	0.15	.15
PT	54.28 ± 35.86	65.47 ± 25.50	0.25	.25
OMPUT	14.76 ± 5.21	16.84 ± 6.34	0.24	.24
Male				
SART	52.63 ± 9.68	52.77 ± 11.47	0.97	.35
3MST	147.47 ± 85.64	104.63 ± 22.96	0.02	<.05
WST	53.89 ± 47.60	87.21 ± 89.85	0.15	<.05
PT	78.11 ± 45.45	87.81 ± 73.29	0.62	.22
OMPUT	32.63 ± 11.72	30.96 ± 9.71	0.61	.37

DISCUSSION

The artificial intelligence-generated calisthenics training program was implemented for five weeks among a group of untrained collegiate students. Within-group comparisons were done. It was found that the AIGCTP group has significantly increased lower extremity flexibility and muscular endurance of the core and upper extremities. The result of the present study was supported by a previous study about an AI-based assistant training system and its causal relationship with specific physical fitness parameters. In the previous study, muscular endurance was found in the upper extremities. The aforementioned training system has improved the muscular endurance of vertical pulling muscles. (Du,2021), This was observed by increased pull-up repetitions after administering the aforementioned training program. In the present study, the artificial intelligence-generated calisthenics training program also improved the muscular endurance of the upper extremities, mainly horizontal pushing. The previous study's AI-generated training program improved sprinting and standing long jumps (Du, 2021). This can also be indirectly explained by the present study result, as sprinting performance positively correlates with muscular endurance of hip flexion and extension and the core (Ogata et al., 1998; Delecluse, 1997; Phyne et al., 2008). Also, the correlation between prone bridge performance and sprint acceleration was established (Afandi et al., 2021; Shaikh et al., 2019; Santos et al., 2019). This means that the improvement in sprinting performance due to artificial intelligence-prescribed exercise is indirect in the muscular endurance of the core. This is the same case for the flexibility of the lower extremities. It was suggested that the flexibility of the hamstring muscles has a high correlation with long jump performance (Rahim et al., 2020). Also, flexibility training on the lower extremities has increased jumping ability (Konstantinos et al., 2015). This signifies that the improvement in jumping performance is due to artificial intelligence-prescribed exercise (Du, 2021), which is also an indirect improvement in flexibility. The AIGCTP insignificantly improved the participants' Cardiovascular and muscular endurance. No previous studies directly support the insignificant causal relationship between the AI-generated training program and the physical fitness components, cardiovascular endurance, and muscular endurance of the lower extremities. With this, the result of the study was authentic. However, the result should be reviewed and validated by replicating the study. However, it can be explained by principles of training. The training program created through artificial intelligence was suggested to be lacking in generating specific exercises that may improve the muscular endurance of the lower extremities. Training specificity is essential in training to promote desired adaptations (Coffey & Hawley, 2017; Brearley & Bishop, 2019). Although lower extremities exercises were suggested, these target the isotonic contraction of the lower extremities muscles. The wall sit test tested the isometric contraction capability of the said muscle group. As for cardiovascular endurance, there was also a problem with the specificity of the generated training. An aerobic calisthenics training program was more specific and suitable than a calisthenics training program in improving cardiovascular endurance (Sakinah et al., 2022). The effects of the aforementioned training program were also investigated with sex-specificity. For female participants, all of the selected health-related physical fitness components were insignificantly changed by the training program. As for male participants, only the flexibility of the lower extremities and muscular endurance of the upper extremities were significantly increased by the implementation of the training program. With this, the result of the present study is suggested to be validated by exploring the causal relationship of Artificial Intelligence integration on fitness modalities and physical fitness components. Moreover, sex-specific investigations should be carried out.

Also, within-group comparisons were done for the human-generated calisthenics training program, which was implemented for 5 weeks. It improves the flexibility and muscular endurance of the lower and upper extremities of the participants. On flexibility, the calisthenics training program was established to improve the hamstring muscles after implementation of it in students (Sakinah et al., 2022), soccer players (Panihar & Rani, 2022), and the sedentary population (Girish & Mathew, 2022). Also, calisthenics exercise improves the muscular endurance of the upper extremities among the obese population (Sakinah et al., 2022). Specifically, push was found to be an effective modality in improving the upper extremity muscular endurance and strength (Kotarsky et al., 2018); as for lower extremities' muscle endurance, calisthenics was as effective as repetitive sprinting in improving the muscularity of the lower extremities (Ölmez & Akcan, 2021). Also, Improved muscular endurance through improved aerobic endurance was seen in cyclists who engaged in calisthenics training (Kul et al., 2022). For those with cerebral palsy, calisthenic exercises improve the lower extremities' muscularity and aerobic capacity (You and Choi, 2022). No previous studies directly support the insignificant causal relationship between the Human-generated training program and the core's physical fitness components, cardiovascular endurance, and muscular endurance. With this, the result of the study was authentic. However, the result should be reviewed and validated by replicating the study. However, it can be explained by principles of training. The training program was lacking in generating specific exercises that may improve the muscular endurance of the core muscles. Training specificity is essential in training to promote desired adaptations (Coffey & Hawley, 2017; Brearley & Bishop, 2019). Although core exercises were suggested, these target the isotonic contraction of the core muscles. The plank test tested the isometric contraction capability of the said muscle group. As for cardiovascular endurance, there was also a problem with the specificity of the generated training. An aerobic calisthenics training program was more specific and suitable than a calisthenics training program in improving cardiovascular endurance (Sakinah et al., 2022). The effect of the training program based on sex was also studied. For female participants, the training program insignificantly changed all of the selected health-related physical fitness components. Male participants were observed to have increased all of the health-related physical fitness components except the muscular endurance of the core. With this, the result of the present study is suggested to be validated by exploring the causal relationship between calisthenics and physical fitness components. Moreover, sex-specific investigations should be carried out.

Between-group comparisons were done for the AIGCTP and HGCTP groups. Despite sex, it was found that the cardiovascular endurance of the HGCTP group was significantly superior to that of the AIGCTP group. This was the same case for the male and female participants. For males, muscular endurance of the lower extremities of those HGCTP was significantly higher than that of the AIGCTP. Studies about the comparison of AI-generated training programs versus traditional training programs were few.

CONCLUSION

The artificial intelligence-generated calisthenics training program effectively improved the flexibility of the lower extremities and muscular endurance of the core and upper extremities. Specifically, females do not improve in all health-related physical fitness components. However, males had an improvement in both flexibility of the lower extremities and muscular endurance of the upper extremities. The human-generated calisthenics training program was suggested to be effective in improving the flexibility and muscular endurance of the lower and upper extremities of all the participants. Specifically, females do not improve in all health-related physical fitness components. Improvements in Flexibility of the lower extremities, cardiovascular endurance, and muscular endurance of the lower and upper extremities were seen in male participants. Between-group comparisons were done for the AIGCTP and HGCTP groups. Despite sex, it was found that the cardiovascular endurance of the HGCTP group was significantly superior to that of the AIGCTP group. This was the same case for the male and female participants. For males, muscular endurance of the lower extremities of those HGCTP was significantly higher than that of the AIGCTP. The result of the study implies that the use of artificial intelligence in exercise prescription for fitness is possible. However, it still cannot be substituted for professional-made fitness training programs as they are still superior in some aspects. It was suggested that further studies should be done on this subject in order to validate the results of the study. Future researchers should focus on validating the results of the present study through replication and expanding the physical fitness components used as dependent variables of the study. Lastly, a higher duration of the training programs is also recommended.

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