ORIGINAL ARTICLE

The effect of 10-week wholebody calisthenics training program on the muscular endurance of untrained collegiate students

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ABSTRACT

The study aimed to investigate the effects of calisthenics exercise on muscular endurance by implementing a 10-week whole-body calisthenic training program on 183 randomly selected untrained collegiate students (108 females, 75 males). A two-group pretest-posttest design was employed (Control group = 88; Experimental group = 95), accompanied by three muscular endurance field tests—the one-minute push-up test, planking test, and wall sit test—to thoroughly observe the probable effects of the training program on this fitness component. The pretest involved administering fitness tests, followed by the 10-week training program for the experimental group. The control group was instructed to engage in one hour of preferred physical activity three times a week for 10 weeks. Post-testing was completed by administering the same fitness tests. The normality of the data was assessed using the Shapiro-Wilk test. For intragroup comparison, the Wilcoxon signed-rank test was used, while for intergroup comparison, the Mann-Whitney U test was employed. Among females in the Controlled Group, the One Minute Push-up Test showed a significant improvement from a mean of 10.80 (±7.18) to 13.97 (±7.53) (p < .00001*), while the PT increased from 68.83 (±37.80) to 78.79 (±41.50) (p = .00036*), and the Wall Sit scores rose from 48.90 (±27.04) to 65.59 (±31.86) (p < .00001*). In males, the Wall Sit demonstrated a significant improvement from 58.15 (±26.47) to 83.88 (±50.28) (p = .00022*). Conversely, the Experimental Group exhibited significant improvements in all three tests for both females and males. Inter-group comparisons revealed the Experimental Group's significantly higher mean scores in the One Minute Push-up Test (24.50 vs. 18.17, p = .00494*), PT(107.87 vs. 79.85, p = .01044* for males), and Wall Sit (112.34 vs. 83.88, p = .01255*). Both female and male participants in the Experimental Group showed significant improvements in the One Minute Push-up Test, Planking Test, and Wall Sit compared to the Control Group, with consistently higher mean scores across all tests. The study recommends testing more muscle groups, like those involved in pulling and hip movements, to better understand calisthenics' impact on overall endurance and suggests additional field tests for a more complete evaluation.

Keywords: Physical education, Calisthenics, Untrained, Muscular endurance.

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INTRODUCTION

Muscular endurance denotes the ability of a muscle to repeatedly generate force, sustaining contraction over a defined duration (Hockey, 1973). This attribute is distinctive for each muscle group in the human body (Radovanović, 2013). Characterized by the capacity of a muscle group to endure repeated force application against resistance, muscular endurance is a crucial fitness component (Priya & Devi, 2023). Within the context of fatigue, it manifests as the performance of repetitive body actions (Ković et al., 2013). Beyond its role as a health-related fitness component, muscular endurance serves as a negative predictor for Body Mass Index (BMI) (Ding & Jiang, 2020; Garcia-Hermoso et al., 2019) and the risk of obesity (Garcia-Hermoso et al., 2019). Furthermore, elevated levels of this parameter are associated with reduced all-cause mortality and a decreased risk of cardiovascular diseases (Corder et al., 2019). As a vital health-related fitness component necessitating maintenance and enhancement, muscular endurance contributes significantly to weight management and disease prevention.

Despite its health-related significance, low muscular endurance may engender challenges in an individual's athletic, physiological, and psychological domains (Walker et al., 2017). Research indicates that diminished muscular endurance, even within the context of health-focused considerations, significantly impacts athletic performance and heightens the risk of injuries (Ambegaonkar et al., 2012). Moreover, it is associated with metabolic risk factors such as triglycerides, HOMA index, and inflammatory markers (Cohen et al., 2014). Cardiovascular diseases, including those of a metabolic nature, exhibit correlations with low muscular fitness (Artero et al., 2012). The ramifications extend beyond physical health, impacting psychological well-being. Individuals with lower muscular fitness are susceptible to anxiety (Kandola et al., 2020), while adolescents and middle-aged women with insufficient levels of this fitness component face an increased risk of psychiatric conditions such as schizophrenia and depression (Ortega et al., 2012; Ganasarajah et al., 2019). Premature mortality is a noteworthy concern, particularly in the context of an elevated risk of suicide before the age of 55 (Ortega et al., 2012). Thus, beyond serving as a health-related fitness component, low muscular endurance harbours alarming implications across athletic, cardiovascular, and mental health domains.

Body weight exercises and calisthenics

Bodyweight exercises involve utilizing the exerciser's body weight as resistance, performed without additional equipment such as free weights or machines (Chaves et al., 2020; Punia & Kulandaivelan, 2019; Ebert et al., 2018; Ebert et al., 2017). Positioned as an alternative to resistance training with equipment (Stephenson & Swank, 2004), bodyweight exercises are deemed joint-friendly and widely accessible, often considered a cornerstone in training regimens (Klisaric' et al., 2021). Functioning as closed-chain exercises, they engage multiple joints with resistance either distanced away from or toward the body part, connecting to a surface (Karp, 2008). Research affirms their positive impact on various fitness components, including cardiorespiratory endurance, muscle fitness, balance, flexibility, body composition, posture (Cigerci et al., 2020; Archila et al., 2021; Thomas et al., 2017), and exercise economy (McDaniel et al., 2020). Beyond serving as a training modality, bodyweight exercises find application in rehabilitative settings (Comfort et al., 2015; Ryan et al., 2021). Consequently, bodyweight exercises present themselves as a viable alternative to traditional resistance training, contributing to physical fitness enhancement and rehabilitation interventions.

Effectiveness of body weight training on muscular endurance

Body weight training, or calisthenics, emerges as a viable and effective approach to improving body composition (Thomas et al., 2017; Cigeri & Genc, 2020; Poti, K., & Upadhye, 2019), even in athletic populations (Bayrakdar et al., 2019). Its utility extends to physical education programs, where it enhances muscular endurance of the core and upper extremities (Guerra et al., 2019). Noteworthy gains in flexibility are observed among elderly individuals (Farinatti et al., 2014; Pinar et al., 2014), school-aged boys (Srivastava et al., 2013), and combative athletes, particularly in hip and trunk flexibility (Marwat et al., 2021; Esan & Okebiorun, 2015). The components of muscular fitness, encompassing both strength and endurance, are believed to be positively influenced by calisthenics (Faraley et al., 2020; Kotarsky et al., 2018; Pinar et al., 2014; Marwat et al., 2021). In addition to health-related fitness components, improvements in sports-related fitness components, such as balance (Genc, 2020) and coordination (Marwat et al., 2021), are documented outcomes of this training approach. Importantly, bodyweight training is found to positively influence exercise economy in conditions such as chronic obstructive pulmonary disease (Basso-Vanelli et al., 2016), demonstrating efficacy comparable to cycle exercise training and traditional resistance training (Duruturk et al., 2016; Greulich et al., 2014). The benefits extend to individuals with diabetes, where similar significant effects are noted (Nordin & Zainuddin, 2019; Kimura et al., 2020; Kong et al., 2022). While existing literature establishes the efficacy of bodyweight training across various fitness components and rehabilitative contexts, limited attention has been dedicated to investigating its specific impact on the muscular endurance of the upper extremities.

The outcomes of this study are anticipated to contribute valuable insights into the effects of calisthenics on human well-being. In the realm of fitness, the findings may propose a targeted program for enhancing the muscular endurance of the upper extremities among students. Additionally, the study promotes an alternative avenue for achieving muscular fitness, alleviating the constraints associated with equipment-dependent regimes.

METHODOLOGY

Research design

The investigation employed a true experimental design, specifically a two-group pre-test post-test design, to assess the impact of a 10-week whole-body calisthenic program on muscular endurance. The study encompassed an initial phase wherein selected muscular endurance tests were administered as pre-tests, followed by the implementation of a structured 10-week calisthenic training program. Subsequently, the study concluded with the administration of the same fitness tests to evaluate potential changes in muscular endurance.

Participants and sampling method

The study included 183 collegiate students selected through random sampling, with 95 assigned to the experimental group and 88 to the control group. Originally, the participants were 200 but five participants from the experimental group and 12 from the control group withdrew from the study.

Sex profile of the participants

Table 1 exhibits the random designation of the participants to either the Controlled Group or the Experimental Group, with a focus on sex distribution. The control group consisted of 24 male participants and 64 female participants, while the Experimental Group comprised 51 male participants and 44 female participants.

Table 1. Distribution of the sex profile of the participants.

	Controlled	Experimental
Male	24	51
Female	64	44

Demographic profile of the participants

Table 2 shows that participants were divided into a Controlled Group and an Experimental Group, each subjected to different conditions. The control group exhibited a mean age of 19.90 ± 1.29 years, while the Experimental Group had a slightly higher mean age of 20.08 ± 1.46 years. Notably, the Experimental Group also had a higher mean height of 1.79 ± 1.43 meters, compared to the Controlled Group's mean height of 1.64 ± 0.09 meters. Regarding weight, participants in the Controlled Group had a weight of 52.68 ± 10.90 kilograms, whereas those in the Experimental Group displayed a slightly greater mean weight of 58.61 ± 12.82 kilograms. Furthermore, the Body Mass Index (BMI) of the control group was calculated to be 19.63 ± 3.335, while the Experimental Group demonstrated a higher mean BMI of 21.36 ± 4.52.

Table 2. Demographic profile of the participants.

	Controlled group	**Experimental group**
Age (years)	19.90 ± 1.29	20.08 ± 1.46
Height (meters)	1.64 ± 0.09	1.79 ± 1.43
Weight (kg)	52.68 ± 10.90	58.61 ± 12.82
Body Mass Index	19.63 ± 3.335	21.36 ± 4.52

Instruments

Muscular endurance for the lower and upper body, as well as the core, was assessed using body part-specific tests. The wall sit test, designed for lower body endurance, particularly targeting the quadriceps group, was employed (Jyothi & Sujaya, 2018). For upper body endurance, focusing on the arms, upper back, and pectoral muscles, the one-minute push-up test was administered (Fischer et al., 2016). Additionally, the planking test, acknowledged as one of the best and practical methods for assessing core endurance, was utilized (Pardeshi et al., 2020). The selection of these instruments was based on their validity in measuring fitness components and their relevance to specific body parts.

Data gathering procedure

Prior to testing, participants were briefed on the study details, and they participated in active rest 24 hours before the test administration. A light warm-up and whole-body stretching were conducted before the fitness tests. The testing sequence comprised the plank test administered first, followed by the wall sit test, and concluded with the one-minute push-up test. To guarantee full recovery and optimize performance, participants were provided with 5-10 minutes of recovery time between each test.

The experimental group participated in a 10-week whole-body calisthenic program, involving three sessions per week. Each session comprised six exercises targeting the upper and lower body, as well as the core. The training program progressed by introducing progressively more kinetically demanding exercises. The specific details of the 10-week whole-body calisthenic program are outlined in the table below.

Table 3. 10-week whole-body calisthenic program.

	Upper body	**Core**	**Lower body**
Week 1 to 3	Wall push up	Dead bug position	Kneeling hip hinge
Training Program A	Chair push up	Straight leg Lift raise	Standing double leg hip hinge
Week 4 to 6	Negative Knee Push up	Dead bug with hip, knee, and shoulder extension (Same side)	Chair Squat
Training Program B	Knee push up	Leg raise	Squat with chair as assistance

Week 7 to 10	Negative Push ups	Dead bug with hip, knee, and shoulder extension (Contralateral)	Body weight squats
Training Program C	Push ups	Isometric hold leg raise	Hinge Squat

In contrast, the control group received instructions to partake in a minimum of three weekly p sessions, each lasting one hour, engaging in self-selected physical activities for the duration of 10 weeks. Following this period, all participants underwent identical fitness tests. The aforementioned procedure was replicated during the pretest phase.

Data analysis

The normality of the data was assessed using the Shapiro-Wilk test. For intragroup comparison, the Wilcoxon signed-rank test was used, while for intergroup comparison, the Mann-Whitney U test was employed.

Potential ethical issue

Participants received a comprehensive briefing on the study, inclusive of a discussion of their rights within the research framework. After this, informed consent was asked through the signing of a consent letter by the participants. Subsequently, a Physical Readiness Questionnaire was administered to ascertain the absence of any underlying medical conditions among participants. Ultimately, it is imperative to underscore that the data acquired will be handled with the utmost commitment to confidentiality and will be shared with the owner upon request.

RESULTS

Muscular endurance testing data of controlled group

Table 4 shows that the Controlled Group's muscular endurance was assessed through pre-test and post-test measurements, focusing on the One Minute Push-up Test, Planking Test, and Wall Sit. Among females, the One Minute Push-up Test exhibited a significant improvement from a mean of 10.80 (±7.18) in the pre-test to 13.97 (±7.53) in the post-test (p < .00001*), as indicated by a notable Z-value of -5.1922. Similarly, the PT displayed significant enhancement with mean scores of 68.83 (±37.80) in the pre-test and 78.79 (±41.50) in the post-test (p = .00036*), reflected by a Z-value of -3.3844. The Wall Sit scores also showed a substantial increase from a mean of 48.90 (±27.04) in the pre-test to 65.59 (±31.86) in the post-test (p < .00001*), supported by a Z-value of -5.8232. Among males, while the One Minute Push-up Test and PT did not exhibit significant changes (p = .24196 and .14457, respectively), the Wall Sit scores demonstrated a significant improvement from a mean of 58.15 (±26.47) in the pre-test to 83.88 (±50.28) in the post-test (p = .00022*), with a corresponding Z-value of -3.5225.

Table 4. Within group comparison of the controlled group.

	Pre-test	Post-test	*p*-Value	Z-Value
Female				
OMPUT(Repetitions)	10.80 ± 7.18	13.97 ± 7.53	< .00001*	-5.1922
PT(Seconds)	68.83 ± 37.80	78.79 ± 41.50	.00036 *	-3.3844
WT(Seconds)	48.90 ± 27.04	65.59 ± 31.86	< .00001.*	-5.8232
Male				
OMPUT(Repetitions)	17.59 ± 10.45	18.17 ± 10.66	.24196	-0.7042
PT(Seconds)	91.76 ± 45.62	79.85 ± 37.97	.14457	-1.0601
WT(Seconds)	58.15 ± 26.47	83.88 ± 50.28	.00022*	-3.5225

Muscular endurance testing data of experimental group

On the other hand, among the experimental group, significant improvements were observed in all three fitness tests. The One Minute Push-up Test scores increased from a mean of 11.45 (±7.63) in the pre-test to 18.41 (±9.74) in the post-test (p < .00001*), supported by a Z-value of -5.3099. Similarly, the PT demonstrated a substantial enhancement with mean scores of 58.86 (±28.31) in the pre-test and 81.40 (±32.99) in the post-test (p < .00001*), indicated by a Z-value of -5.3858. The Wall Sit scores also showed a significant increase from a mean of 54.92 (±33.84) in the pre-test to 78.15 (±35.93) in the post-test (p < .00001*), with a corresponding Z-value of -5.415. Among males, all three exercises exhibited highly significant improvements. The One Minute Push-up Test scores increased from a mean of 16.82 (±7.59) in the pre-test to 24.50 (±9.33) in the post-test (p < .00001*), accompanied by a Z-value of 10.23. The PT demonstrated substantial enhancement, with mean scores of 81.73 (±44.96) in the pre-test and 107.87 (±40.39) in the post-test (p < .00001*), reflected by a Z-value of -4.706. The Wall Sit scores also significantly increased from a mean of 67.22 (±34.72) in the pre-test to 112.34 (±55.76) in the post-test (p < .00001*), supported by a Z-value of -6.154.

Table 5. Within group comparison of the experimental group.

	Pre-test	**Post-test**	***p*-Value**	**Z-Value**
Female				
OMPUT(Repetitions)	11.45 ± 7.63	18.41 ± 9.74	< .00001*	-5.3099
PT(Seconds)	58.86 ± 28.31	81.40 ± 32.99	< .00001*	-5.3858
WT(Seconds)	54.92 ± 33.84	78.15 ± 35.93	< .00001*	-5.415
Male				
OMPUT(Repetitions)	16.82 ± 7.59	24.50 ± 9.33	< .00001*	10.23
PT(Seconds)	81.73 ± 44.96	107.87 ± 40.39	< .00001*	-4.706
WT(Seconds)	67.22 ± 34.72	112.34 ± 55.76	< .00001*	-6.154

Muscular endurance testing data of male controlled group and experimental group

Table 6 shows the male participants in both the Controlled and Experimental scores in the fitness tests administered. In the One Minute Push-up Test, the Experimental Group exhibited a significantly higher mean score of 24.50 (±9.33) compared to the Controlled Group's mean of 18.17 (±10.66), with a p-value of .00494* and a corresponding Z-value of 2.58389. Similarly, in the Planking Test, the Experimental Group demonstrated a significantly improved mean score of 107.87 (±40.39) compared to the Controlled Group's mean of 79.85 (±37.97), with a p-value of .01044* and a Z-value of 2.30563. The Wall Sit scores also showed a significant increase in the Experimental Group, with a mean of 112.34 (±55.76), compared to the Controlled Group's mean of 83.88 (±50.28), resulting in a p-value of .01255* and a Z-value of 2.23748.

Table 6. Male between-group comparison.

	Control	**Experimental**	***p*-Value**	**Z-Value**
OMPUT(Repetitions)	18.17 ± 10.66	24.50 ± 9.33	.00494*	2.58389
PT(Seconds)	79.85 ± 37.97	107.87 ± 40.39	.01044*	2.30563
WT(Seconds)	83.88 ± 50.28	112.34 ± 55.76	.01255*	2.23748

Muscular endurance testing data of female controlled group and experimental group

Table 7 shows that the female participants in the One Minute Push-up Test, the Experimental Group, demonstrated a significantly higher mean score of 18.41 (±9.74) compared to the Controlled Group's mean of 13.97 (±7.53), with a p-value of .01255* and a corresponding Z-value of 2.23748. However, in the Planking Test, no significant difference was observed between the two groups, with the Experimental Group having a mean score of 81.40 (±32.99) and the control group having a mean of 78.79 (±41.50), resulting in a *p*-value of .2327 and a Z-value of -0.73468. In the Wall Sit, the Experimental Group exhibited a significantly improved mean score of 78.15 (±35.93) compared to the Controlled Group's mean of 65.59 (±31.86), with a *p*-value of .00734* and a Z-value of -2.44477.

Table 7. Female between-group comparison.

	Control	**Experimental**	***p*-Value**	**Z-Value**
OMPUT(Repetitions)	13.97 ± 7.53	18.41 ± 9.74	.01255*	2.23748
PT(Seconds)	78.79 ± 41.50	81.40 ± 32.99	.2327	-0.73468
WT(Seconds)	65.59 ± 31.86	78.15 ± 35.93	.00734*	-2.44477

Muscular endurance testing data of controlled group

Table 8 represents that all of the participants in the Controlled Group, in the One Minute Push-up Test, demonstrated a significant improvement, with mean scores increasing from 12.65 (±8.69) in the pre-test to 15.11 (±8.64) in the post-test (*p* < .00001*), reflected by a Z-value of -4.7851. Similarly, the PT showed a notable enhancement, with mean scores changing from 75.15 (±41.14) in the pre-test to 79.08 (±40.36) in the post-test (*p* = .0116*), supported by a Z-value of -2.2709. The Wall Sit scores exhibited a substantial increase, with mean scores rising from 51.42 (±27.05) in the pre-test to 70.58 (±38.35) in the post-test (*p* < .00001*), indicated by a Z-value of -6.7733.

Table 8. Within-group comparison of the controlled group (All participants).

	Pre-test	**Post-test**	***p*-Value**	**Z-Value**
OMPUT(Repetitions)	12.65 ± 8.69	15.11 ± 8.64	< .00001*	-4.7851
PT(Seconds)	75.15 ± 41.14	79.08 ± 40.36	.0116*	-2.2709
WT(Seconds)	51.42 ± 27.05	70.58 ± 38.35	< .00001*	-6.7733

Muscular endurance testing data of experimental group

On the other hand, Table 9. Shows that the Experimental Group, in the One Minute Push-up Test, displayed a significant improvement, with mean scores increasing from 14.62 (±8.68) in the pre-test to 21.83 (±10.45) in the post-test (p < .00001*), evidenced by a Z-value of -8.0455. Similarly, the PT showed a substantial enhancement, with mean scores changing from 69.89 (±37.89) in the pre-test to 92.40 (±38.45) in the post-test (*p* < .00001*), supported by a Z-value of -7.0837. The Wall Sit scores exhibited a remarkable increase, with mean scores rising from 60.51 (±33.78) in the pre-test to 94.07 (±48.40) in the post-test (*p* < .00001*), indicated by a Z-value of -8.2074.

Table 9. Within-group comparison of the experimental group (All participants).

	Pre-test	**Post-test**	***p*-Value**	**Z-Value**
OMPUT(Repetitions)	14.62 ± 8.68	21.83 ± 10.45	< .00001*	-8.0455
PT(Seconds)	69.89 ± 37.89	92.40 ± 38.45	< .00001*	-7.0837
WT(Seconds)	60.51 ± 33.78	94.07 ± 48.40	< .00001*	-8.2074

Muscular endurance testing data of controlled group and experimental group

Lastly, in Table 10, all of the participants in the Experimental Group, in the One Minute Push-up Test, exhibited a significantly higher mean score of 21.83 (±10.45) compared to the Controlled Group's mean of 15.11 (±8.64), with a *p*-value of < .00001* and a corresponding Z-value of 4.32364. In the Planking Test, the Experimental Group also showed a significantly improved mean score of 92.40 (±38.45) compared to the Controlled Group's mean of 79.08 (±40.36), resulting in a *p*-value of .00427* and a Z-value of 2.62966.

Likewise, in the Wall Sit, the Experimental Group demonstrated a significantly higher mean score of 94.07 (±48.40) compared to the Controlled Group's mean of 70.58 (±38.35), with a *p*-value of < .00001* and a Z-value of 4.2203.

Table 10. Between-group comparison between the controlled and experimental group.

	Control	**Experimental**	***p*-Value**	**Z-Value**
OMPUT(Repetitions)	15.11 ± 8.64	21.83 ± 10.45	< .00001*	4.32364
PT(Seconds)	79.08 ± 40.36	92.40 ± 38.45	.00427*	2.62966
WT(Seconds)	70.58 ± 38.35	94.07 ± 48.40	< .00001*	4.2203

DISCUSSION

Muscular endurance of the upper and lower extremities, as well as the abdomen, improved after 10 weeks of 3 hours per week of physical activity among female participants. However, among males, only the lower extremities' muscular endurance was positively affected. Some studies support the effect of regular physical activity on other physical fitness components. It was studied that it is a way to improve musculoskeletal fitness (Warburton et al., 2001). Additionally, it was investigated to have a positive correlation among anthropometric measurements such as waist-to-hip ratio and muscle mass, and other fitness components which consist of cardiorespiratory fitness and grip strength (Irēna et al., 2012). Physical activity and cardiovascular fitness were investigated to have a small to moderate correlation, suggesting their positive correlation (Piccinno et al., 2017). In a study about graduate and undergraduate female students, it was shown that the low physical inactivity identified through the International Physical Activity Questionnaire has been the reason for both groups having an insufficient level of physical fitness (Osipov et al., 2021). All participants in the control group exhibited an improvement in all muscular endurance pertaining to specific body parts after 10 weeks of 3 hours per week of physical activity. The results of the study among the control group strengthen the literature about the causal and correlational relationship between physical activity and physical fitness.

Regardless of the sex of the participants, the 10-week whole-body calisthenics training program improved the upper and lower extremities and abdomen of the participants. Not only muscular endurance but also body composition as one of the health-related components was established to be improved by calisthenics in non-athletic populations, as investigated by previous studies (Thomas et al., 2017; Cigeri & Genc, 2020; Poti, K., & Upadhye, 2019). This is the same case for athletic populations (Bayrakdar et al., 2019). Flexibility of elderly populations (Farinatti et al., 2014; Pinar et al., 2014) and school-aged boys (Srivastava et al., 2013) was also improved by incorporating calisthenics exercises. All participants in the experimental group exhibited an improvement in all muscular endurance pertaining to specific body parts after the 10-week whole-body calisthenics training program. The effectiveness of the calisthenics training program, regardless of sex, was not only seen in muscular endurance as the present study suggests but also in other aspects of physical fitness as the previous studies investigated.

Male participants of the experimental group had higher muscular endurance of the upper and lower extremities, and abdomen in comparison with the control group counterpart. The same improvement was seen in literature about the effect of calisthenics as a training program in terms of body composition. Male footballers who underwent an 8-week calisthenic training program were observed to have better body weight, body mass index, fat percentage, and fat mass in comparison with athletes who focused on football training alone (Cigerci & Geno, 2020). In posture and strength of horizontal and vertical pulling, it was observed that untrained males who were administered the calisthenic training protocol had better performance in the said parameters compared to another group (Thomas et al., 2017). Male tennis players who underwent the same training program experienced an improvement in their static and dynamic balance (Genç, 2020). Literature about the positive effect of the calisthenic training program on the male population was supported by the present study. Among the male population, the training program is deemed effective in improving other fitness components. Female participants of the experimental group had higher muscular endurance of the upper and lower extremities in comparison with the control group counterpart. However, there is a lack of evidence on the difference between the groups in abdominal muscular endurance. Some studies about the effect of calisthenic training programs among females supported the results of the present study. Against Pilates, it was investigated that 6 months of calisthenics exercise is better in improving coordination of the lower extremities (Kaya et al., 2012). The present study adds up to a few studies investigating the effect of the calisthenics training program on the female population. This will not only lead to additional knowledge about the topic but also in the representation of females in exercise. The participants of the experimental group had higher muscular endurance of the upper and lower extremities, and abdomen in comparison with the control group counterpart.

In a 10-week study involving 3 hours of weekly physical activity, sex-specific outcomes were observed. Females exhibited improved muscular endurance in the upper and lower extremities and abdomen, while males experienced enhancement primarily in the lower extremities. The study supported the positive relationship between regular physical activity and musculoskeletal fitness, correlating anthropometric measurements with fitness components. All of the Control group participants demonstrated improved muscular endurance across body parts, reinforcing the connection between physical activity and fitness. On the other hand, the 10-week calisthenics program, regardless of sex, positively impacted upper and lower extremity muscular endurance, body composition, and flexibility. Males in the experimental group showed superior muscular endurance compared to controls, aligning with literature on calisthenics' benefits for body composition and strength in male athletes. Among females, calisthenics improved upper and lower extremity muscular endurance, contributing to the understanding of its effects on female populations and emphasizing its overall effectiveness in enhancing fitness components for both sexes.

CONCLUSION

The study investigated the effect of a 10-week whole-body Calisthenics training program on muscular endurance in Controlled and Experimental Groups, examining One Minute Push-up Test, Planking Test, and Wall Sit scores. In the Controlled Group, females displayed significant improvements in all fitness testing, while males showed a notable enhancement in Wall Sit scores. Conversely, the Experimental Group, both among females and males, exhibited highly significant improvements in all three tests. Inter-group analyses revealed that the Experimental Group outperformed the control group significantly in the one-minute push-up Test, PT(males only), and Wall Sit. Intra-group comparisons demonstrated consistent improvements in the Controlled Group, and highly significant changes in the Experimental Group, particularly in the One Minute Push-up Test. Overall, the 10-week whole-body Calisthenics training program yielded positive outcomes, with the Experimental Group consistently surpassing the Controlled Group in muscular endurance across three tests, emphasizing the effectiveness of the training program.

The study employs three specific muscular endurance tests, focusing on horizontal pushing, lumbar flexion, and squat movements. To comprehensively evaluate the effectiveness of calisthenics in enhancing overall muscular endurance, it is crucial to investigate other muscle groups involved in horizontal pulling, lumbar extension, and hip-dominant movements. This broader examination will provide a more comprehensive understanding of the impact of calisthenics on fundamental movements. To address the limitations of the study, additional field tests should be incorporated as instruments, offering a more holistic perspective on muscular endurance and contributing to a well-rounded evaluation of the effectiveness of the intervention.

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