applied sciences

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Effects of Isometric and Isotonic Training on Health-Related Fitness Components in Young Adults

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Abstract: Isometric and isotonic exercises are important modes of resistance training for enhancement of athletic performance. However, less is known about their effects on fitness and health in recreationally physically active individuals. This study evaluates the effect of isometric and isotonic training protocols on health-related fitness components in young university students. A group of one hundred males (18–24 years) underwent a 12-week isotonic and isometric training program (two days per week, 45 min per session). They were randomized into two groups, group A (n = 50) and group B (n = 50). While group A underwent the isotonic resistance training, the group B completed isometric resistance training. Prior to and after training programs, body mass index (BMI) was measured and the bench press 1RM test, sit-ups test, sit and reach test, and 12 min run/walk test were performed. Results showed significant improvements in BMI, bench press 1RM test, sit-ups test, sit and reach test, and 12 min run/walk test after both isotonic and isometric training protocols. The isotonic training group increased in BMI by 2.70%, bench press 1RM by 34.45%, number of sit-ups by 24.13%, sit and reach distance by 29.12%, and 12 min run/walk distance by 19.82%. Isometric training group increased in BMI by 1.96%, bench press 1RM by 14.23%, number of sit-ups by 7.80%, sit and reach distance by 6.92%, and 12 min run/walk distance by 6.99%. A comparison of these training protocols revealed that the isotonic group improved significantly more than the isometric group in the bench press 1RM (20.22%), number of sit-ups (16.33%), and sit and reach distance (22.2%) but not in the 12 min run/walk distance (12.83%) and BMI (0.74%). These findings indicate that both isotonic and isometric resistance training protocols improve health-related fitness components in young adults; however isotonic training is more efficient than isometric training in increasing their muscle strength, muscular endurance, and flexibility.

Keywords: cardiovascular endurance; flexibility; muscular endurance; muscle strength; resistance training

Citation: Azeem, K.; Zemková, E. Effects of Isometric and Isotonic Training on Health-Related Fitness Components in Young Adults. *Appl. Sci.* **2022**, *12*, 8682. https://doi.org/10.3390/app12178682

Academic Editor: Roger Narayan

Received: 26 January 2022
Accepted: 25 August 2022
Published: 30 August 2022

1. Introduction

Isotonic training is very popular among athletes as well as recreationally active individuals. Isotonic exercise includes a shortening/concentric contraction of the agonist while simultaneously displaying lengthening/eccentric of the antagonist (or vice versa). Isotonic training allows utilizing the stretch-shortening cycle, i.e., muscle lengthening immediately followed by muscle shortening [1]. Benefits of isotonic resistance training are as follows: isotonic exercises can be performed with or without gym equipment, they improve the size and muscle strength, increase the cardiovascular fitness, support performing daily activities without fatigue, improve bone density, and reduce the risk of sports injuries.

On the other hand, isometric exercise is a static exercise, so when the force is applied, the length of the muscle remains the same. Isometric muscle function has subjectively

two different modes of performance; one can either hold isometrically, and thus resist an impacting force, or push isometrically and work against a stable resistance [2]. The benefits of the isometric resistance training are as follows: isometric exercises (hold for 10 to 30 s) can be performed with or without gym equipment, they improve the flexibility of joints, manage reducing blood pressure, and can be used for rehabilitation [3].

Resistance training has a positive effect on lower limb power (i.e., vertical jump height) and strength (i.e., 1RM squats and bench press) [4], flexibility [5], and muscular endurance [6], improving dynamic balance, maintaining healthy body weight, increasing the range of motion and overall muscular fitness [7], and improving the quality of life [8]. Following the initial stage of the program with low weights (<60% of 1RM), the intensity, complexity, and movement speed gradually increased on a weekly basis. Free weights have a naturally stirring, constantly changing external moment arm with single joint exercises and multiple changing external moment arms in multiple joint exercises [9]. Multi machines use a mechanically designed and engineered eccentrically shaped pulley known as a cam that varies the external moment arm [10].

Incorporating both isotonic and isometric resistance exercises in regular training programs may increase muscle strength and the range of motion, and may have many health-related benefits improving quality of life [11]. Participation in resistance training has been associated with reduced central adiposity and reduced unhealthy fat gain, It can also lead to weight loss [12]. The aquatic form of these exercises may stimulate improvements in measures of fatigue [13]. However, resistance training protocols need to be age-adjusted [14] with appropriate volume for improving muscle strength and hypertrophy [15].

Overall, both isotonic and isometric trainings are beneficial for athletes as well as the general population [16] and are recommended for the enhancement of their performance. However, less in known about their effects on fitness and health in recreationally physically active adults participating exclusively in university physical education classes. Therefore, the aim of this study was to compare the effects of isometric and isotonic training protocols on health-related fitness components in young university students. We hypothesized that isotonic exercises will be more effective in enhancing health-related fitness components compared to isometric exercises.

2. Method

2.1. Participants

A one hundred male students were selected randomly from the classes of Physical Education PE-102 at King Fahd University of Petroleum and Minerals (KFUPM) in Saudi Arabia. The selected untrained participants were divided into two groups: the isotonic resistance training group (n = 50, age 19.32 $\pm$ 0.65 years, height 1.70 $\pm$ 0.07 m, body mass 67.80 $\pm$ 13.04 kg) and isometric resistance training group (n = 50, age 19.26 $\pm$ 0.59 years, height 1.72 $\pm$ 0.59 m, body mass 69.56 $\pm$ 11.31 kg). The purpose of this research study was explained and doubts cleared to the students.

2.2. Training Protocols

Both isotonic and isometric training groups underwent a 12-week training, two times a week, each session for 45 min (Table 1). The participants from both groups have similar a training history at a base level. Exercises for the isotonic resistance training group included sitting leg presses, leg extensions and curls, bench presses, chest presses, shoulder presses, high pull downs (front), rowing (sitting), arm curls, and triceps push downs. Exercises for the isometric resistance training group included squats isometric, leg extensions isometric, push-ups isometric, isometric bench exercises, side lateral isometric extensions, front isometric raises, sitting lats isometric extensions, hanging on chin-up bar, triceps isometric extensions, and barbell isometric curls. For isotonic training, the regimen was as follows: week 1 to 4, low-intensity training (2 sets $\times$ 15 reps $\times$ 30 s rest between the sets); week 5–8, medium-intensity training (2 sets $\times$ 12 reps $\times$ 1 min rest between the sets), and week 9 to 12, high-intensity training (2 sets $\times$ 8 reps $\times$ 1 min rest between the sets). For

isometric training, the regimen was as follows: week 1 to 4 (2 sets × 20 s on, 10 s break), week 5 to 8 (2 sets × 30 s on, 10 s break), week 9 to 12 (2 sets × 40 s on, 10 s break).

Table 1. Details of the resistance training programs.

12 weeks	Resistance training program
Weekly	Two sessions
Duration of each session	Forty five minutes
Isotonic exercise (group-I)	Ten
Isometric exercise (group-II)	Ten
Tests performed before and after 12-week training schedule	Pre and post-training testing of health-related fitness variables
Resistance training protocols	Frequency, Intensity, Time, and Type

2.3. Health-Related Fitness Tests

Prior to and after training programs, participants performed tests assessing health-related fitness components (Table 2). The body mass index (BMI) of the participants was calculated (weight in kg/height in m^2) using measurements of body weight by electronic weighing machine and height by a stadiometer in meters. Furthermore, they underwent tests of muscle strength (1RM bench press), muscular endurance (sit-ups test for thirty seconds), flexibility (sit and reach test), and cardiovascular endurance (12 min run/walk test). The data were collected and recorded during pre- and post-training at Building 11, KFUPM, Saudi Arabia.

Table 2. Dependent and independent variables.

BMI Muscle Strength Flexibility Muscular Endurance Cardiovascular Endurance	Dependent
Isotonic Group Isometric Group	Independent

2.4. Statistical Analysis

Data analysis was performed using the SPSS program for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA). To determine the mean changes from pre- to post-training, an independent *t*-test was used. The significance level was set at $p < 0.05$. The percentage changes in health-related fitness variables were also computed. Data are presented as mean ± standard deviation.

3. Results

The data of the isotonic training group and the isometric training group on health-related fitness variables from the pre- to post-training is presented in the Table 3.

The analysis of results revealed that the isotonic training group improved in body mass index (from 23.32 ± 0.65 to 23.95 ± 0.92, $p < 0.00$), bench press 1RM (from 41.80 ± 14.06 kg to 56.20 ± 12.68 kg, $p < 0.00$), number of sit-ups (from 23.54 ± 3.70 to 29.22 ± 3.88, $p < 0.00$), sit and reach distance (from 22.84 ± 7.27 cm to 29.49 ± 7.55 cm, $p < 0.00$), and 12 min run/walk distance (from 1226.0 ± 199.9 m to 1469.0 ± 249.4 m, $p < 0.00$). Similarly, the isometric training group improved in body mass index (from 22.86 ± 0.77 to 23.31 ± 1.00, $p < 0.00$), bench press 1RM (from 42.44 ± 11.44 kg to 48.48 ± 10.38 kg, $p < 0.00$), number of sit-ups (from 24.10 ± 3.05 to 25.98 ± 2.88, $p < 0.00$), sit and reach distance (from 23.12 ± 6.54 cm to 24.72 ± 6.55 cm, $p < 0.00$), and 12 min run/walk distance (from 1272.0 ± 180.0 m to 1361 ± 198.1 m, $p < 0.00$).

Table 3. Data for the health-related fitness components prior to and after 12-week isotonic and isometric training programs in young adults.

Health-Related Fitness Variables	Group	Pre-Test		Post-Test		*p* Values
		Mean	SD	Mean	SD	
Body Mass Index (values)	Isotonic	23.32	0.65	23.95	0.92	0.00
	Isometric	22.86	0.77	23. 31	1.00	0.00
Bench Press 1RM (kg)	Isotonic	41.80	14.06	56.20	12.68	0.00
	Isometric	42.44	11.44	48.48	10.38	0.00
Sit-Ups for 30 s (number)	Isotonic	23.54	3.70	29.22	3.88	0.00
	Isometric	24.10	3.05	25.98	2.88	0.00
Sit and reach (cm)	Isotonic	22.84	7.27	29.49	7.55	0.00
	Isometric	23.12	6.54	24.72	6.55	0.00
12 min run/walk (m)	Isotonic	1226.0	199.9	1469.0	249.4	0.00
	Isometric	1272.0	180.0	1361.0	198.1	0.00

Both isotonic and isometric groups have shown significant improvements in all health-related fitness components (Table 4). The isotonic training group increased in BMI by 2.70%, bench press 1RM by 34.45%, number of sit-ups by 24.13%, sit and reach distance by 29.12%, and 12 min run/walk distance by 19.82%. The isometric training group increased in BMI by 1.96%, bench press 1RM by 14.23%, number of sit-ups by 7.80%, sit and reach distance by 6.92%, and 12 min run/walk distance by 6.99%.

Table 4. Percentage changes in health-related fitness variables from pre- to post-tests in the isotonic and isometric training groups.

Variables	Isotonic Group	Isometric Group	Between-Group Differences
	% Changes	% Changes	% (*p* Values)
Body mass index	2.70	1.96	0.74 (0.081)
Bench press 1RM	34.45	14.23	20.22 (0.01)
Number of sit-ups for 30 s	24.13	7.80	16.33 (0.02)
Sit and react distance	29.12	6.92	22.2 (0.00)
12 min run/walk distance	19.82	6.99	12.83 (0.05)

However, a comparison between these groups revealed that the isotonic group improved more than the isometric group in all health-related fitness components, such as body mass index (0.74%), bench press 1RM (20.22%), number of sit-ups (16.33%), sit and reach distance (22.2%), and 12 min run/walk distance (12.83%). However, significant between-group differences were revealed in the bench press 1RM ($p < 0.01$), number of sit-ups ($p < 0.02$), and sit and reach distance ($p < 0.00$) but not in body mass index ($p > 0.081$) and 12 min run/walk distance ($p > 0.05$).

4. Discussion

The isometric and isotonic groups underwent different training regimes; both types of exercise have their own benefits on health-related fitness components. Although both groups improved significantly from pre- to post-training, a greater improvement in muscle strength, muscular endurance, and flexibility was revealed after isotonic compared to isometric training.

These findings are in agreement with a previous study that also identified significant improvements in fitness variables following weight training [17]. Similarly, the resistance training of different intensities improved strength, anaerobic power, and explosive power in male subjects [18]. Kim et al. [19] analyzed the effects of isotonic, isokinetic, and isometric

exercises of ankle joint muscles on lower extremity muscle activity and balance control and found that muscle fatigue from the three exercise methods produced a decline in muscle activity and balance control. There is a progressive association between muscle strength, power, and enhancement of the quality of life [20]. For instance, isometric exercises increase sustainability and strength in people with joint inflammation, improve the range of motion among injured people, and reduce their resting blood pressure [21].

Physical activity also plays an important role in physical and psychological development among children and adolescents and enhancing their health status [22]. As has been shown, eight weeks of resistance training improves lower body isometric strength thigh pull in adolescents to a greater extent than in children [23]. A systematic review by Peitz et al. [24] revealed that maturation affects plyometric and resistance training outcomes differently, with the former eliciting greater adaptations pre-peak height velocity (PHV) and the latter around- and post-PHV. Different types of resistance training (e.g., body weight, free weights) are effective in improving measures of muscle strength (e.g., maximum voluntary contraction) in untrained children and adolescents [24]. Participation in resistance training programs in schools may provide a basis for attending physical education university classes focused on the enhancement of muscle strength and power as a part of overall physical fitness development.

Our study showed that two days of isotonic and isometric resistance exercises per a week in the duration of 45 min are sufficient for improving fitness level in young university students. However, it has to be taken into account that isotonic training is more effective in the enhancement of health-related fitness components compared to isometric training.

5. Conclusions

Both isotonic and isometric resistance training programs have shown significant improvements in health-related fitness components, such as BMI, bench press 1RM, number of sit-ups, sit and reach distance, and 12 min run/walk distance in young adults. However, the isotonic training group showed a greater performance improvement compared to the isometric training group. Significant between-group differences were revealed in the bench press 1RM test, sit-ups test, and sit and reach test but not in the 12 min run/walk test and BMI. These findings indicate that both isotonic and isometric resistance training programs improve health-related fitness components in young adults; however, isotonic training is more efficient than isometric training in increasing their muscle strength, muscular endurance, and flexibility.

Author Contributions: Writing—original draft, K.A. Conceptualization, K.A.; methodology, K.A.; formal analysis, K.A.; investigation, K.A.; data curation, K.A.; writing—original draft preparation, K.A. and E.Z.; writing—review and editing, K.A. and E.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The scientific committee of the Physical Education Department and DSR at KFUPM in Saudi Arabia approved this study (ref ID–PE-104-2021).

Acknowledgments: The authors thank the authorities of Physical Education Department, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia and the subjects for the help in completion of this study. We extend thanks for the publication fee supported by DSR, King Fahd University of Petroleum & Minerals, Saudi Arabia.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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