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Original Article

Impact of CrossFit Training Programs on the Physical Health and Sociogenic Somatic Anxiety of Adolescents

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Abstract

Background: A decline in adolescent health holds significant repercussions for public health. Promoting exercise is essential to improve physical and mental health among youth. This study aimed to explore the effect of CrossFit training programs on the physical health and sociogenic somatic anxiety of adolescents.

Methods: In March 2023, 100 adolescents were openly recruited from eight middle schools in Jinhua, China. The participants, were divided equally into control and experimental groups, experienced either traditional or CrossFit training, respectively, over nine weeks. Evaluation measures included the analysis of social physique anxiety, body esteem, physical self-efficacy, and general physical health before and after the exercise program.

Results: Post-intervention data demonstrated marked reductions across all facets of the social physique anxiety scale, including worries about public scrutiny, anxiety from social comparison, and discomfort related to one's physical self-image, more so in the experimental group ($P<0.05$). Likewise, assessments of the physical self-perception profile and physical self-efficacy scale were enhanced, again with the experimental cohort displaying more pronounced improvements ($P<0.05$). Results from biophysical function evaluations indicated significant health improvements post-intervention, with noted advancements in lung capacity, aerobic fitness by the standing long jump, and muscular endurance as assessed by grip strength, sit-up, and push-up counts, primarily in the experimental group ($P<0.05$).

Conclusion: CrossFit training offered considerable advantages by reducing social physique anxiety and enhancing adolescents' body esteem and physical self-efficacy. The program stimulated improvements in body composition, cardiorespiratory fitness, muscle strength, and flexibility.

Keywords: CrossFit training; Adolescent health; Physical well-being; Social physique anxiety

Introduction

The health status of adolescents gradually declining becomes a significant public health issue (1). Among China's students aged 7–19, physical fitness has reportedly decreased significantly, particularly in explosive strength, endurance, and speed, whereas the obesity rate among adoles-

cents continues to rise steadily. Furthermore, the physical condition of Chinese adolescents is gradually deteriorating, with noticeable changes in body composition and a 3% increase in obesity rates over the past five years (2). As societal beauty standards evolve, robust physical fitness is becoming a primary pursuit for boys, whereas many adolescent girls are driven to exercise and stay fit for a slender and toned physique. Psychologically, excessive emphasis on body image among adolescents can lead to a loss of confidence, decreased overall self-esteem, and heightened anxiety levels, thereby significantly affecting their mental health and personality negatively. A lack of physical activity is known to be a major factor contributing to the declining health of adolescents. Consequently, enhancing adolescents' health through increased physical education is a critical issue that sports educators urgently need to address.

CrossFit training has become increasingly popular in recent years, particularly in Europe and North America. This training system emphasizes "functional movements, high-intensity, and varied" principles. CrossFit training integrates fundamental movements from disciplines such as gymnastics, track and field, and weightlifting. The key characteristic of CrossFit is the requirement for practitioners to complete prescribed training tasks as quickly as possible, or to perform as many repetitions as possible within a set time frame. Compared with traditional fitness and conditioning programs, CrossFit training engages multiple joint-muscle groups rather than isolating individual muscle groups. This holistic approach to physical development can effectively mobilize the body's overall capabilities and thus enhance the participant's comprehensive athletic qualities. For example, CrossFit training can effectively enhance the physical fitness of fitness enthusiasts (3), improve physical fitness and promote the psychological health development of students (4). Compared with traditional fitness training and physical training, CrossFit training pays more attention to the comprehensive development of the body and improves the overall sports quality of the subjects. CrossFit training can effectively increase the anaerobic and aerobic capacity of university students taking elective badminton courses, enhance core strength, improve cardiopulmonary function, and improve the performance of badminton-specific sports (5). Compared with regular fitness and bodybuilding training courses, CrossFit training can better improve the body composition, body shape, physical fitness, and cardiopulmonary function of university students majoring in bodybuilding (6). Likewise, CrossFit training can significantly improve the lower-limb explosive power, reaction speed, speed endurance, and cardiopulmonary endurance of basketball players, as well as improve the performance of athletes in actual combat (7). CrossFit training has also reportedly exerted a positive effect on the physical fitness and psychological health development of adolescents.

The intervention of CrossFit training is particularly important for the physical and mental health development of adolescents. While conventional fitness and physical training have certain effects on their physical and mental health, they tend to focus on the training of single muscle groups and appear to be monotonous, resulting in low participation and persistence among adolescents. Therefore, identifying an intervention method suitable for the overall physical fitness of adolescents and improving their social physique anxiety is crucial. CrossFit training is an inclusive, universal, comprehensive, and novel training method. It is primarily based on functional movements or multi-joint training, combining metabolic regulation, weightlifting, and gymnastics. It requires participants to complete these combined training sessions at high intensity. This can lead to more comprehensive development of the physical and mental health of the participants. Accordingly, this study adopted a CrossFit training program to intervene in adolescents. Through a designed controlled experiment, we analyzed its impact on the physical fitness and social physique anxiety of adolescents.

Materials and Methods

Research objects

This study, conducted in March 2023, openly recruited 100 adolescent participants from eight high schools in Jinhua, Zhejiang, China. Utilizing a random-number method, these participants were divided into two groups: a control group and an observation group, each comprising 50 subjects. The control group comprised 35 males and 15 females, aged 19–24 years, with an average age of (22.16±1.05) years and a BMI of (24.15±1.52) kg/m^2. The parents' educational levels were: middle school (13 participants), high school (38 participants), and university (49 participants). The observation group comprised 33 males and 17 females, aged 19–24 years, with an average age of (22.03±1.12) years and a BMI of (24.03±1.42) kg/m^2. The parents' educational levels were as follows: middle school (12 participants), high school (36 participants), and university (47 participants). No statistically significant differences existed between the two groups in terms of age, gender, BMI, and parental educational level.

The study was approved by the Human Ethics Review Committee of Zhejiang Normal University (approval number: ZSRT202032). All participants provided informed consent and voluntarily participated in the survey.

Methods

This study used an experimental approach: the experimental period was from March to June 2023. During the trial period, confounding factors were controlled as follows: 1) all participants were healthy, had a history of physical activity, and refrained from any aerobic and anaerobic exercise during the experiment while maintaining similar sleep duration and dietary intake. 2) Throughout the nine-week training process, polar heart rate monitors were used to monitor the participants' heart rates in real-time, allowing for better control and observation of the exercise load. 3) For all participants, the training duration was the same, and the results were assessed by three primary investigators after the experiment.

Intensity Regulation in Exercise: 1) a polar heart rate monitor was used to track real-time heart rate, ensuring exercise intensity reaches over 75% with a heart rate range of 140–160 bpm. 2) Participants maintained a 45 min training session, with a 5–10 min warm-up and 5–10 min cool-down.

The CrossFit training program consisted of the following components. Gymnastics (G): This included partner exercises, bar jumps, Russian twists, dynamic planks, pull-ups, sit-ups, sled pulls, goat raises, handstand push-ups, assisted pull-ups, burpees, box jumps, static plank holds, push-ups, sit-ups, full squats, half squats, overhead presses, and shoulder taps. Weightlifting (W): This included overhead squats, bodyweight squats, barbell squats, alternating dumbbell presses, dumbbell shoulder presses, back squats, sumo deadlifts, shoulder presses, and dumbbell snatches.

Metabolic Conditioning (M): This included hill sprints, lunge jumps, interval runs, steady-state runs, jump rope, and 10 and 50m shuttle runs.

The training program was structured in three phases. During the first 3 weeks (phase 1), the intensity was moderate. The intensity was gradually increased in the subsequent 4–6 weeks (phase 2) and 7–9 weeks (phase 3). Proper warm-up and cool-down were emphasized, and hydration and appropriate athletic attire were required during the training sessions.

Table 1: Crossfit Training Schedule

Day	*First week*	*Second week*	*Third week*
Monday	M	G	W
Wednesday	GW	MW	MG
Friday	MGW	GMW	MWG

Regular Training. For engaging in periodic training with progressively increasing intensity, the details were as follows. 1) Core Strength: Perform seated knee tucks, sit-ups, alternating leg raises from a supine position, prone alternate arm-leg taps, Russian twists, and wall sit. 2) Flexibility: Execute leg stretches behind the body, straight-arm compressions, standing forward bends, seated leg presses, and similar exercises. 3) Agility: Conduct relay races and 10 min shuttle runs. 4) Stamina: Undertake endurance runs. 5) Upper and Lower Limb Strength: Train with multifunctional gym equipment. 6) Lower Limb Strength: Incorporate reverse kicks, lunge kick-starts, Achilles tendon stretches, frog jumps, elastic band leg pulls, and full squats, among others. Table 2 shows the training schedule details.

Table 2: Schedule of Regular Training Sessions

Variable	*Monday*	*Wednesday*	*Friday*
First week	Flexibility, Core Strength	Flexibility, lower limb strength	Endurance Quality
Second week	Flexibility, Core Strength	Agility	Endurance Quality
Third week	Flexibility, Upper Body Strength	Flexibility, lower limb strength	Flexibility, Core Strength
Fourth week	Flexibility, Full Body Strength	Flexibility, agility	Endurance Quality
Fifth week	Flexibility, Lower Body Strength	Upper and lower limb strength	Endurance Quality
Sixth week	Core Strength, Flexibility, Upper Body Strength	Flexibility, endurance	Upper and Lower Limb Strength
Seventh week	Flexibility, Agility	Flexibility, lower limb strength	Endurance and Flexibility
Eighth week	Agility, Lower Body Strength	Core strength, agility, upper limb strength	Endurance and Lower Limb Strength
Ninth week	Flexibility, Core Strength, Upper Body Strength	Agility, upper and lower limb strength	Endurance Quality

Observation indicators

1) Social Physique Anxiety Scale. This study utilized the Social Physique Anxiety Scale (SPAS) compiled by Xu to assess the adolescent subjects (8). The questionnaire included three dimensions: discomfort with social comparison (3 items), unease about physical self-presentation (6 items), and concern over negative evaluations by others (6 items), totaling 15 items. It used a Likert 5-point scoring system ranging from "completely agree" (5 points) to "completely disagree" (1 point). Lower scores on the scale indicated reduced social physique anxiety among adolescents. The questionnaire had considerable reliability and validity, with an internal consistency coefficient ranging from 0.78 to 0.95 and a Cronbach's alpha of 0.91.

2) Physical Self-Perception Profile. The assessment was conducted utilizing the physical self-perception profile (PSPP) revised by Xu and Yao (9), originally compiled by Fox. This inventory included a main scale, physical self-worth (PSW), which reflected confidence, pleasure, satisfaction, and pride in one's body. The four subscales were as follows: the physical condition subscale (PC; concerning confidence in exercise situations, maintaining exercise capacity, physical vigor, and health status); and the sports competency subscale (SC; including confidence in sports competition environments, the ability to learn sports skills, and specialized athletic abilities). Each subscale contained 6 items and scored from 1 to 4; thus, each subscale had a total of 4 to 24 points. The inventory demonstrated significant reliability and validity.

3) Physical Self-Efficacy Scale. The assessment used the physical self-efficacy scale (PSEP) developed by Sun and his team (10). It comprised 10 items divided into two dimensions: confidence in one's physical capabilities and perception of physical aptitude. This scale ranged from self-perception of being "very fit" to "not fit at all" and used a 1–6 point Likert scale, showing commendable reliability and validity.

4) Body Composition and Cardiopulmonary Function. For evaluating body composition and cardiopulmonary function, measurements of stature and mass were made using a biometric scale. Waist–hip ratio and body fat percentage (BFP) were determined through a body-composition analysis instrument, whereas pulmonary volume was measured with a spirometer.

5) Muscle Strength and Flexibility. In assessing muscular strength and flexibility, participants' reach-and-stretch capacity was measured using a flexometer. Abdominal core endurance was evaluated through a one-minute sit-up count with an ergometer, and explosive leg strength was determined by a horizontal-leap measure using a long-jump gauge.

Statistical analysis

Comprehensive data analysis was performed using SPSS 22.0 (IBM Corp., Armonk, NY, USA). Normally distributed quantitative data were expressed as the mean and standard deviation ($\bar{x} \pm s$). For comparisons within groups, paired t-tests were conducted, whereas for analyses between different groups, independent t-tests were used. Categorical variables were examined using the chi-squared test. A p-value less than 0.05 was considered to denote statistical significance.

Results

Comparative Analysis of SPAS Scale Scores Pre- and Post-Intervention in Two Adolescent Cohorts

Following the intervention, in adolescents from both cohorts, scores significantly decreased for various SPAS scale items, including social comparison anxiety, concern over negative evaluations from others, and discomfort associated with physical self-presentation. The decrease in these indicators was especially notable in the observation group (P<0.05), as detailed in Table 3.

Table 3: Comparison of SPAS scale scores before and after intervention in two groups of adolescents

Variable	*Control group*		*Observation group*	
	Before intervention	After intervention	Before intervention	After intervention
Social comparison anxiety	2.69±0.09	2.47±0.06*	2.73±0.08	2.01±0.06*#
Concern over negative evaluations from others	2.86±0.09	2.69±0.06*	2.89±0.08	2.34±0.05*#
Discomfort associated with physical self-presentation	3.21±0.11	2.95±0.08*	3.25±0.10	2.42±0.07*#

Note: Compared with before intervention, *P<0.05; compared with the control group after intervention, #P<0.05.

Comparison of PSPP scale scores before and after intervention in two groups of adolescents

Compared with before the intervention, the scores of the PSPP scale items including PSW, SC, PC, AB, and PF significantly increased after intervention in both groups of adolescents. The observation group showed a more significant increase (P<0.05), as detailed in Table 4.

Table 4: Comparison of PSPP scale scores before and after intervention in two groups of adolescents

	Control group		***Observation group***	
	Before intervention	After intervention	Before intervention	After intervention
PSW	2.02±0.05	2.21±0.06*	2.00±0.06	2.78±0.09*#
SC	2.10±0.08	2.35±0.09*	27±0.04	2.69±0.07*#
PC	2.12±0.05	2.51±0.09*	2.08±0.07	2.89±0.09*#
AB	2.19±0.09	2.48±0.11*	2.16±0.07	2.96±0.08*#
PF	2.23±0.08	2.45±0.09*	2.21±0.06	2.86±0.12*#

Note: Compared with before intervention, *P<0.05; compared with the control group after intervention, #P<0.05.

Comparison of PSEP scale scores before and after intervention in two groups of adolescents

Compared with before the intervention, the scores of the PSEP scale significantly increased after the intervention in both groups of adolescents, with the observation group showing a more significant increase (P<0.05), as detailed in Table 5.

Table 5: Comparison of PSEP scale scores before and after intervention in two groups of adolescents

Variable	***Control group***		***Observation group***	
	Before intervention	After intervention	Before intervention	After intervention
PSEP scale scoring	30.61±6.59	33.29±6.95*	30.84±6.62	38.74±7.10*#

Note: Compared with before intervention, *P<0.05; compared with the control group after intervention, #P<0.05.

Changes in body composition and cardiopulmonary function indices before and after intervention in two groups of adolescents

Compared with before the intervention, the biophysical function (BPF) values significantly decreased after the intervention in both groups of adolescents, whereas lung function and the 12-minute run values significantly increased. The observation group showed more notable improvements (P<0.05); Table 6.

Table 6: Changes in body composition and cardiopulmonary-function indices before and after intervention in two groups of adolescents

Variable	***Control group***		***Observation group***	
	Before intervention	After intervention	Before intervention	After intervention
Body Mass Index (BMI) (kg/m^2)	24.15±1.52	23.86±1.46	24.03±1.42	23.71±1.39
Waist–Hip Ratio (WHR)	0.86±0.03	0.82±0.05	0.84±0.04	0.79±0.06
Body Fat Percentage (BFP)	28.98±2.54	25.87±2.39*	29.05±2.48	16.58±2.10*#
Lung Function (ml)	3546.25±215.69	3875.26±229.85*	3539.32±239.87	4032.29±265.80*#
12 min Run (m)	2149.85±210.25	2314.62±187.63*	2132.52±206.53	2698.62±258.94*#

Note: Compared with before intervention, *P<0.05; Compared with the control group after intervention, #P<0.05.

Changes in muscular strength and flexibility indices before and after intervention in two groups of adolescents

Compared with before the intervention, significant increases were observed in standing long jump, grip strength, sit-ups, and push-ups after the intervention in both groups. The observation group showed a more significant increase (P<0.05), as detailed in Table 7.

Table 7: Changes in muscular strength and flexibility indices before and after intervention in two groups of adolescents

Variable	*Control group*		*Observation group*	
	Before intervention	After intervention	Before intervention	After intervention
Vertical Jump (cm)	33.56±2.54	39.74±2.66*	33.43±2.49	43.05±3.15*#
Grip Strength (N)	26.98±5.41	36.87±6.25*	26.87±5.32	42.96±6.43*#
Sit-Ups (reps)	25.11±2.30	27.41±2.44*	25.06±2.28	30.08±3.08*#
Push-Ups (reps)	24.87±2.19	25.98±2.25*	24.76±2.14	28.96±2.32*#
Sit and Reach (cm)	17.52±1.63	18.02±3.51	17.47±1.58	18.69±2.98

Note: Compared with before intervention, *P<0.05; Compared with the control group after intervention, #P<0.05.

Discussion

The data presented in Table 1 indicated a notable reduction in the levels of social comparison anxiety, apprehension concerning adverse evaluation, and unease related to physical self-representation in the intervention group compared with the control group. These findings substantiated the effectiveness of the CrossFit training regimen in mitigating social physique anxiety among adolescents, corroborating observations similar to the findings of He et al. (11). Social physique anxiety is understood as the distress an individual experiences due to the judgment of others regarding their outward physical appearance, as opposed to any anxiety associated with the actual performance of physical tasks. Individuals grappling with social anxiety often endure significant discomfort in various social interactions, marked by nervousness and an awkward demeanor, especially when public speaking or encountering unfamiliar individuals (12). Consequently, the opinions of others are given exaggerated focus, which significantly impacts their self-awareness (13). The CrossFit model, which combines aerobic exercises with strength training and varied high-intensity workouts, cultivates favorable psychological attitudes toward health among college participants over nine weeks. Participants demonstrate a propensity for active engagement in this more intensive training paradigm compared with conventional physical education sessions, likely fostering enhanced body confidence, self-efficacy, and self-esteem. The physical modifications engendered by CrossFit also likely induce various psychological reactions, contributing to an upsurge in body assurance. A diminution in unease with physical self-presentation, bolstered resilience to negative appraisals, or the accrual of confidence through positive evaluations potentially plays roles. Furthermore, alterations in physical form and amplified physical prowess may attenuate anxiety in scenarios of social comparison, leading to an overarching reduction in social physique anxiety.

Results from Tables 2 and 3 indicated that after the intervention, scores in all dimensions of the PSPP scale (Physical Self-Worth, Sport Competence, Physical Condition, Body Attractiveness, Physical Strength) and the PSEP scale for the observation group were higher than those for the control group. This finding suggested that the CrossFit training program can effectively improve aspects of physical self-esteem and self-efficacy among adolescents, consistent with the findings of Coyne et al. (14). During adolescence, an individual's physical performance and body shape perceptions, widely accepted by society or others, significantly influence bodily self-esteem and self-efficacy (15-17). The CrossFit training program adopted for this study used short-interval, high-intensity workout regimens focusing on functional and compound movements, catering to physical function and fitness training. It led to notable improvements in adolescents' body shape, strength, and bodily attractiveness, building stronger self-confidence, fostering mental health, and elevating levels of physical self-efficacy and self-esteem.

Results from Table 4 post-intervention showed that the BFP in the observation group was lower than that in the control group, whereas pulmonary function and 12 min run tests were better. This finding underscored the effectiveness of the CrossFit program in enhancing body composition and cardiorespiratory fitness among adolescents, consistent with the findings of Ferreira Taet al. (18) BFP is a critical indicator of the degree of slimness or obesity in humans, consisting of visceral and subcutaneous fat. Generally, the latter accumulates around the hips and waist and to varying degrees within visceral organs. A considerable relationship exists between a person's health and the amount of internal body fat; as fat increases, so does cardiovascular strain (19-20). The CrossFit activities adopted in this study such as running, jumping rope, squat jumps, burpees, and push presses were designed to elevate energy expenditure and reduce adolescent body fat. Exercises like hanging leg raises and sit-ups are effective in reducing abdominal fat, thereby diminishing waist size in teenagers. Weighted deep squats, deadlifts, and kettlebell swings are hip-dominant exercises that stimulate the glutes, aiming to reduce fat there and build muscle mass, and thus improving BFP values in adolescents. Moreover, CrossFit's principal application of medium to high-intensity exercise elevates heart rates gradually and increases the oxygenation capacity of the muscles, accelerating breathing rates and exercising the lungs, hence enhancing lung capacity.

Lastly, results from Table 5 post-intervention highlighted that the observation group's performances in the standing long jump, grip strength, sit-ups, and push-ups were all higher than those in the control group. This finding signified that the CrossFit training program can effectively improve muscle strength and flexibility in adolescents, similar to the report of Kaczorowska et al. (21). This improvement may be attributed to exercises such as pull-ups, knees-to-chest, and toes-to-bar incorporated into CrossFit, which gradually enhance grip strength and, alongside movements like "swinging," "pull-downs," and "pull-ups," can also train the forearm musculature (22).

In CrossFit, exercises such as deadlifts and front/back squats enhance participants' lower body strength, whereas jump squats, and box jumps (eccentric contraction exercises) elevate leg power. When participants rapidly increase power-output levels within a short timeframe, their nervous systems become highly stimulated, swiftly contracting muscle fibers and effectively boosting absolute strength and explosive power. Thus, standing long jump performance is improved. The number of push-ups in a minute demonstrates upper-body muscle endurance. Under the CrossFit regimen, participants repetitively cycle through a vast array of movements, leading to a significant build-up of lactic acid. However, given the relatively extended duration of training and short recovery intervals, the body develops muscle strength and endurance against fatigue, thereby increasing the number of push-ups achieved in a minute. Sit-ups are also indicative of abdominal muscle endurance. The CrossFit program includes numerous compound movements that require participants' core muscles to be continuously engaged, thereby amplifying abdominal muscle strength and endurance. Exercises such as hanging leg raises, knees-to-chest, and sit-ups target the abdominal region, enhancing strength and consequently improving the endurance of these muscle groups.

Conclusion

CrossFit training can effectively reduce concerns about body image among adolescents, enhance their physical self-esteem, and increase self-efficacy, which refers to a boost in confidence in their abilities and sense of control. CrossFit can also significantly improve adolescents' body composition, strengthen cardiopulmonary functions, augment muscle strength and flexibility, and offer certain fat-reduction effects, assisting teenagers in maintaining healthy body weight.

Journalism Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interest

The authors declare that there is no conflict of interests.

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