

Effect of green exercise on stress level, mental toughness, and performance of taekwondo athletes

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Dictionary:

Neo-gladiator – a person who trains mix martial arts (MMA) and similar forms of hand-to-hand fighting that do not meet the definition of sport according to the Olympic Charter [51].

Tactics – decisions and actions of players in the contest to gain an advantage over the opposing players [52].

Technique – specific procedures to move one's body to perform the task that needs to be accomplished [52].

Exercise intensity – noun the degree to which a workout is difficult for the exerciser [50].

Exercise intensity – in order to improve physical fitness, exercise must be hard enough to require more effort than usual. The method of estimating appropriate training intensity levels varies with each fitness component. Cardiovascular fitness, for example, requires elevating the heart-rate above normal [50].

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Abstract:

Background and Study Aim: Green exercise, while in direct contact with the actual natural environment, delivers synergetic health benefits for the individuals, and active engagement with nature initiating the stress recovery process. The cognitive aims of this case study is knowledge about the effect of green exercise on stress level and mental toughness and its effect on the performance of junior taekwondo athletes in the competition period.

Material and Methods: Three Latvian national taekwondo athletes (n = 2 females and n = 1 male) aged 17 were selected. All participants had at least ten years of experience in taekwondo. The Depression and Anxiety Stress Scale (DASS), the Vienna Determination Test, and the mental toughness questionnaire were used, and the performance assessment was based on their best results in the International Sweden Taekwondo Competition. The intervention involved twelve 40-minute nature walks, done thrice weekly for four weeks before the competitions.

Results: Group analysis showed significant stress reduction in the Vienna Determination Test ($p = 0.01$) but not in the DASS ($p = 0.17$) or mental toughness metrics (confidence $p = 0.38$, constancy $p = 0.74$, control $p = 0.67$). Athletes A, B, and C had varied stress reductions (22.6% to 75%) and inconsistent changes in mental toughness, with determination improving for all.

Conclusions: Green exercise significantly improved stress levels based on the Determination Test but not on the DASS questionnaire or mental toughness metrics. Individual results showed varied stress reductions, suggesting the potential benefits of nature-based physical activity in competitive settings. Further research is necessary on representative groups of people with different experience of physical activity and also using other tests in order to select a tool with the highest predictive value.

Keywords: attention restoration theory, Depression and Anxiety Stress Scale, recovery, stress reduction theory, Vienna Determination Test

Training intensity – the effort of training. A number of methods are used to establish training intensities which give maximum benefits. These include the lactic acid method, minute ventilation method, and target heart-rate [53].

Zone intensity – heart rate zones are ranges based on a percentage of maximum heart rate. They allow you to control the intensity of your workout and adapt it to your individual needs and training goals. Using the correct heart rate zone when exercising influences the effectiveness of the workout and how much benefit a particular physical activity will bring. The determination of heart rate zones is closely related to the concept of maximum heart rate, which is the maximum number of beats the heart can perform per minute. This value is different for each person. The simplest and most common way to determine maximum heart rate is the formula: 220 minus the person's age, but it is effective mainly for people taking their first steps in sport, when progress is largely related to a large increase in the amount of training [54].

A Likert scale – is a psychometric scale commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research, such that the term (or more accurately the Likert-type scale) is often used interchangeably with rating scale, even though the two are not synonymous (Wikipedia).

1. Introduction

Green exercise refers to physical activity in urban green spaces, such as parks and campuses, maintained with minimal human intervention [1]. Authors of works addressing this issue show that exposure to nature can positively impact mental health, reducing anxiety, depression, and stress [2-5]. Direct engagement with nature through green exercise provides synergistic health benefits and helps initiate the stress recovery process. Additionally, green exercise can serve multiple goals, including social interaction, entertainment, and leisure, increasing physiological and psychological well-being [6].

For instant, examining the relationship between the level of green exposure and physical activity, finding that even low to moderate levels of walking in areas with at least 40% visible greenery positively affect emotions and attention [7]. The findings support the stress reduction theory (SRT) [8] and the attention restoration theory (ART) [9]. Authors of these theories suggest that human evolution has conditioned us to respond beneficially to natural environments [10]. SRT focuses on the emotional and physiological recovery from stress [11], while ART suggests that nature restores attention by providing a break from continuous mental requirements through its inherently fascinating existence [9].

Research results indicates that participating in sports competitions is stressful [12] and originates from various mental, social, environmental, and physical requirements [13]. Results of systematic review by Kondo et al. [14] suggesting that time outdoors reduces stress. According to stress recovery theory, the most significant benefit of natural exposure to stress happens when individuals are already stressed, as nature helps return them to a less stressed situation. Mental toughness is important in effective emotional self-regulation, task focus, and self-confidence [15]. Different models of mental toughness have been suggested, such as Sheard's 3C model [16], which identifies control, constancy, Confidence, and its core components. Athletes with high mental toughness still experience anxiety, stress, and pressure from competitions [17], but they cope better, often viewing such situations as challenges [18]. These athletes are characterized by optimism and commitment during competitions [19]. Research results confirms a relationship between mental toughness and sports performance, with mentally tough athletes excelling in motor and cognitive tasks and achieving better sports results. Mental toughness helps athletes use motor skills effectively under stress, but the exact mechanism behind its impact on performance remains unknown [20, 21].

Taekwondo is characterized by fast, high, and powerful kicks [22] and is recognized as an Olympic combat sport. Combat situations in taekwondo can change fast, leading to extreme changes in emotional and mental situations during competition. Competing athletes should attack and defend immediately while hiding their technical-tactical intention from opponents. The findings of the previous study of combat sports athletes has shown that goal profiles and mental toughness can influence athletes' results [23].

In the scientific literature, there are cognitively valuable results of studies involving neo-gladiators, unfortunately called athletes by the authors of such works (see glossary). Among other things, there is data available that professional group scored higher on the Sports Mental Toughness Questionnaire (SMTQ) regarding confidence, positive cognition, and determination than the semi-professional and amateur groups [24].

Taekwondo is an indoor sport, and in recent years, attention has been drawn to the relationship between nature and adolescents. Research results indicates that adolescents' connection with nature has reduced with increased indoor time. Researchers and practitioners have emphasized that mental toughness is essential in specifying athletic performance [15], contributing over 50% to athletes' success in their contests with opponents [25]. Most Latvian taekwondo athletes showed low to moderate mental toughness [5]. Although mental toughness is considered important for athletic performance, studies on stress and mental toughness in taekwondo athletes are less.

The cognitive aims of this case study is knowledge about the effect of green exercise on stress level and mental toughness and its effect on the performance of junior taekwondo athletes in the competition period.

2. Materials and Methods

Participants

Three 17-year-old Latvian national taekwondo athletes (n = 2 females and n = 1 male) who qualified for the International Taekwondo Competition in Sweden in 2022 were selected. All participants had at least ten years of experience in taekwondo. Athlete A 78 kg (male) weight category; Athlete B 63 kg (female) weight category; Athlete C 63 kg (female) weight category.

Procedure

Depression and Anxiety Stress Scale (DASS)

The Depression and Anxiety Stress Scale (DASS) consists of three self-report scales designed to provide measures of the three related affective states: depression, anxiety, and stress [26]. Each scale contains 14 items, divided into subscales of 2-5 items with similar content. The stress scale measures difficulty relaxing, nervous arousal, easily upset, irritability, over-reactivity, and impatience. Stress scale scores range from 0 to 34. This study used the Latvian version of the DASS [27].

Vienna Determination Test

The Vienna Determination Test [28] is a computerized measurement to evaluate reactive stress tolerance and reaction time through various stimuli. The test features adaptive stimulus presentation, incorporating various types such as colours, tones, and foot pedals. It includes a brief format with clear instructions and takes approximately 6 minutes to complete. Colour stimuli appear on the screen during the test, while acoustic stimuli are delivered via the test system interface. Participants respond by pressing designated buttons on the panel. Results are analysed using Percentile Ranks (PR), with higher ranks indicating better stress tolerance. The PR is categorized into: above average (76-100), average (25-75), and below average (0-24).

Sports Mental Toughness Questionnaire (SMTQ)

The Latvian version of the Sports Mental Toughness Questionnaire (SMTQ) [29] measures mental toughness. This 14-item questionnaire evaluates mental toughness and three subscales: Confidence, Constancy, and Control. Participants rate their responses on a 4-point Likert scale, from (1) not at all true to (4) very true. The SMTQ is grounded in a positive psychology framework, emphasizing an individual's capacity to overcome challenges and the traits that enable them to thrive and develop in any situation. These traits include self-belief, commitment, perseverance, and managing emotions.

Experimental plan

The study was conducted in three distinct phases over the four weeks leading up to the competition. In the initial phase, athletes were introduced to the stress measurement tools, including the DASS, Vienna Determination Test, and SMTQ (measures mental toughness). Specialists explained each testing protocol comprehensively, and athletes were given verbal and visual instructions. During the second phase, athletes completed the Vienna Determination Test, DASS, and SMTQ questionnaires (stage 'pre-test'). Over the following four weeks, the intervention involved green exercise, consisting of walking in natural settings. Athletes participated in five 90-minute taekwondo training sessions each week, along with three sessions of green exercise per week, each lasting 40 minutes, within heart rate zones 1 and 2 (HR 101-141 bpm). After four weeks, athletes again completed the Vienna Determination Test, DASS, and SMTQ questionnaires in the final phase (stage 'post-test'). Performance was evaluated based on the athletes' outcomes in the competition <https://worldtkd.simplycompete.com>.

Statistical analysis

The analyses were conducted using Microsoft Office Excel and JASP version 0.18.3. Data are presented as the mean (M); standard deviations (SD or \pm); minimum (min); maximum (max); degrees of freedom (df); significance level, probability (p); Student's t-distribution (t). The Shapiro-Wilk test was used to assess the normality of the data. A paired sample t-test and a Wilcoxon signed-rank test (W) were used to analyse the data. The percentage differences were used for individual differences.

Ethical approval

This study was approved by the Ethical Committee of the Latvian Academy of Sport Education (Nr. 51813). All procedures followed the ethical standards of the Declaration of Helsinki.

3. Results

The mean stress score of DASS significantly decreased from $M = 29.66$ (severe) to $M = 19.33$ (moderate), indicating a substantial reduction in stress levels among the athletes. The pre-test standard deviation ± 1.52 suggests that the athletes' stress scores were relatively consistent. However, the post-test ± 4.16 indicates greater variability in stress reduction. The mean score of the Vienna Determination Test increased from $M = 35.00$ to $M = 67.00$. The pre-test ± 4.35 and post-test ± 4.58 show similar levels of variability (Table 1).

The mean for the Confidence score decreased ($M = 16.00$ to $M = 14.66$). The pre-test ± 2.64 indicates moderate variability in confidence levels among athletes, while the post-test ± 4.04 suggests increased variability. The mean for Constancy score slightly increased ($M = 13.33$ to 13.66). The pre-test SD 1.52 indicates some variability in constancy levels among the athletes, while the post-test ± 0.57 suggests reduced variability. The mean for the Control score increased from $M = 12.33$ to $M = 13.33$, and the pre-test SD 1.52 indicates moderate variability in control levels among athletes, while the post-test ± 2.08 shows increased variability (Table 2).

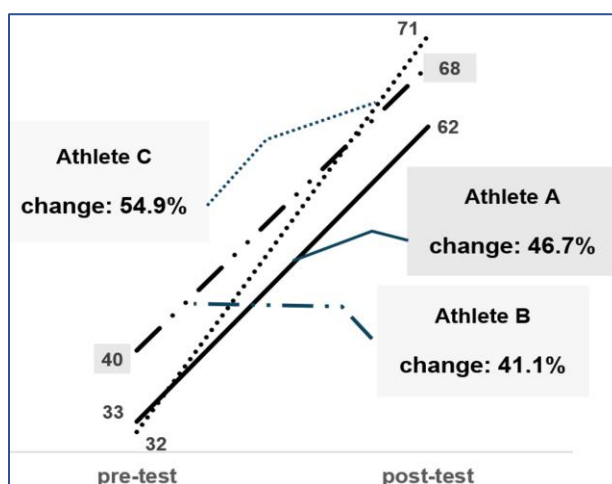
Table 1. Descriptive statistics for stress and SMTQ in the group of taekwondo athletes (n = 3).

Tool	Stage	M & SD (min-max)	Difference
DASS	pre-test	29.66 ±1.52 (28-31)	10.33
	post-test	19.33 ±4.16 (14-24)	
Vienna Determination Test	pre-test	35 ±4.35 (32-40)	32
	post-test	67 ±4.58 (62-71)	

Table 2. Descriptive statistics for mental toughness of taekwondo athletes (n = 3) measures by SMTQ.

Variable	Stage	M & SD (min-max)	Difference
Confidence	pre-test	16 ±2.64 (13-18)	1.34
	post-test	14.66 ±4.04 (11-19)	
Constancy	pre-test	13.33 ±1.52 (12-15)	0.33
	post-test	13.66 ±0.57 (13-14)	
Control	pre-test	12.33 ±1.52 (11-14)	1
	post-test	13.33 ±2.08 (11-15)	

All athletes showed a reduction in DASS stress level, with athletes A (75%) and C (66.6%) experiencing the most significant reductions (Figure 1). Vienna Determination Test demonstrated changes (41.1% to 54.9%), with athlete C showing the highest improvement (Figure 2).

**Figure 1.** Athletes stress tolerance profiles of taekwondo Athletes A, B and C (pre-test and post-test) measured by DASS.

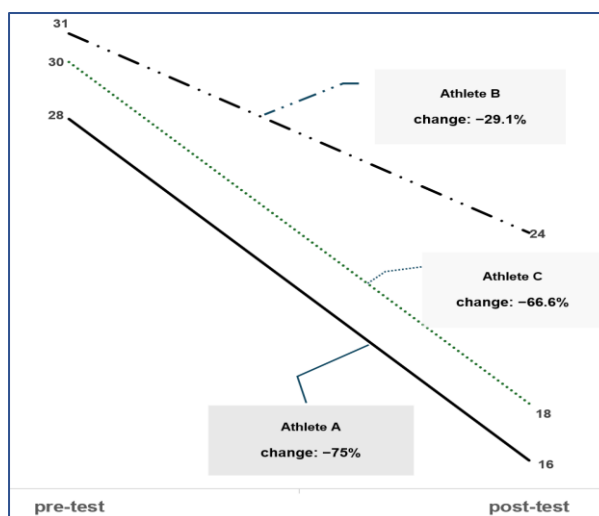


Figure 2. Athletes stress tolerance profiles of taekwondo Athletes A, B and C (pre-test and post-test) measured by Vienna Determination Test.

The Confidence variable of SMTQ decreased for athletes A (-21.4%) and B (-18.1%) but slightly increased for Athlete C (+5.2%). Athlete C showed an improvement in constancy (14.2%), while athlete A (-7.1) experienced a slight decrease, and athlete B remained unchanged (0). For the control variable, athletes B (26.6%) and C (14.2%) exhibited improvements, while athletes A (-27.2%) showed a notable decrease (Figures 3).

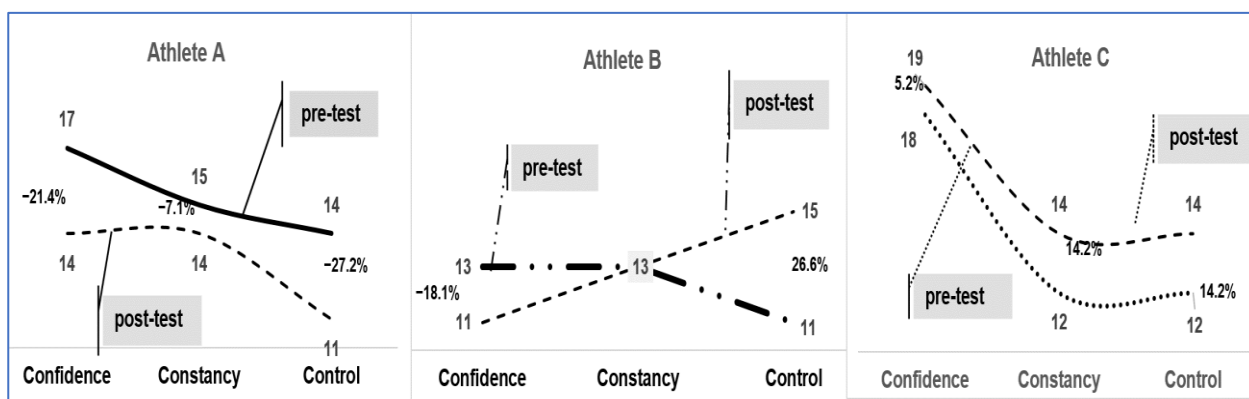


Figure 3. Profile mental toughness of taekwondo Athletes A, B and C (pre-test and post-test) measured by SMTQ.

The Shapiro-Wilk test indicates that the normality assumption was not satisfied for DASS but normality was satisfied for other variables. The results of the Wilcoxon test for DASS showed no significant change ($W = 6.0, p = 0.17 > 0.05$). The results of the paired sample t-test for the Vienna determination test yielded a significant difference, $t(2) = -9.11, p = 0.01 < 0.05$. For the SMTQ variables, there were no significant changes in Confidence $t(2) = 1.1, p = 0.38$, Constancy $t(2) = -0.37, p = 0.74$, and Control $t(2) = -0.48, p = 0.67 > 0.05$ (Table 3).

Table 3. The difference for variables in taekwondo athletes (n = 3) in pre-test and post-test.

Tool	Variable	W	t	df	p
DASS	Stress	6.0			0.17
Vienna Test			-9.11	2	0.01*
mental toughness					
	Confidence		1.10	2	0.38
SMTQ	Constancy		-0.37	2	0.74
	Control		-0.48	2	0.67

DASS Depression and Anxiety Stress Scale; **SMTQ** Sports Mental Toughness Questionnaire; **W** Wilcoxon signed-rank test; **t** statistics; **df** degrees of freedom; **p** significance level, probability; *significant $p < 0.05$.

Athlete Performance

The competition was in Sweden in 2022. The Latvian taekwondo team represented the Junior division, which included two female Athletes B and C in the 63 kg weight category and one male Athlete A in the 78 kg weight category. According to the World Taekwondo, over 1,000 taekwondo athletes compete across various divisions, with registration conducted online. The competition draw sheets indicated that each female Athlete B and C in the 63 kg category faced 12 opponents, while the male Athlete A in the 78 kg category had five opponents. The first female Athlete B in the 63 kg category did not advance and was eliminated. The male Athlete A in the 78 kg category secured third place. The second female Athlete C in the 63 kg category emerged victorious, earning the gold medal.

4. Discussion

This study investigated the effect of green exercise on stress levels, mental toughness, and performance of taekwondo athletes. The group analysis showed significant stress reduction in the Vienna Determination Test but not in the DASS or mental toughness (Confidence, Constancy, Control). Athletes A, B, and C had varied stress reductions and inconsistent changes in mental toughness. Research has supported a positive effect of environmental naturalness on human beings' stress levels while performing physical activity (e.g., sitting, walking, or running) [30]. Our findings showed that Athletes A, B, and C had significant individual changes in stress levels. Previous research has demonstrated that physical activities in natural environments can positively influence stress levels [30]. Our findings highlighted significant individual variations in stress levels among the athletes. The role of nature in stress management is as follows: interactions with the environment let individuals process sensory information from their surroundings or focus deeply and pay no attention to external stimuli [31].

Moreover, Kaplan and Kaplan's attention restoration theory (ART) [9] suggests that interactions with natural environments, especially those related to an individual's goals or purposeful activities, can provide beneficial experiences. These interactions offer relaxation from cognitive demands, potentially reducing cognitive load and

helping psychological recovery, thereby increasing well-being. Our study supports that green exercise with appropriate physical activity can reduce stress. In contrast to our results, some studies have suggested that social interactions during green exercise can influence participants' experiences. For instance, exercising with a partner may reduce feelings of isolation or foster engagement with natural environments [32]. However, social interaction might distract participants from physical activity or the environment [33, 34].

Additionally, nature-based experiences, such as those related to outdoor education, focus on expanding learning to outdoor settings and engaging directly with nature through different sensory modalities [35]. Since taekwondo is primarily an indoor sport, athletes typically train indoors, limiting their exposure to natural experiences. Research has demonstrated that indoor air is significantly more polluted than outdoor air, up to 100 times more contaminated. Prolonged exposure to indoor pollution can lead to dizziness and severe respiratory issues. Spending time outdoors and breathing fresh air can enhance athletes' breathing ability, as research indicates that breathing significantly influences their performance [36, 37]. Additionally, increased alpha wave activity in the temporal lobe has been observed in response to olfactory stimulation from essential oils, which perform the odours encountered in natural environments [38, 39]. Since olfaction is linked to emotion, exposure to nature as a green exercise can reduce stress and improve mood.

In alignment with our study, Jang and So [40] found that training in natural settings can increase taekwondo athletes' performance. Our research findings indicate that green exercise (walking naturally) can benefit stress levels and that the environment in which training occurs plays a crucial role in psychological well-being. The green exercise regimen (12 sessions) was associated with reduced stress and notable performance results (first and third places) at the International Taekwondo Competition in Sweden. These results support Kellmann's scissors model of stress and recovery, which posits that optimal athletic performance is achieved when there is a balance between stress and recovery. According to this model, stress and recovery can be visualized as the two sides of a pair of scissors; optimal performance occurs when both sides are balanced. Performance decreases when excessive stress levels and inadequate recovery occur [41].

Berger and McLeod [42] suggest that nature is a medium that deeply influences individuals, allowing them to reconnect with their physical, psychological, and spiritual selves through experiential interaction with the natural world. Engaging actively with nature increases participant satisfaction [32]. Our study revealed that Athletes A, B, and C experienced varying changes in mental toughness, which aligns with previous findings indicating that Latvian taekwondo athletes have low to moderate levels of mental toughness [5]. Both environmental conditions and physical activity can impact mental toughness. Thelwell et al. [43] concluded that mental toughness is often developed through experiences in specific environmental settings. Chen and Cheesman [24] identified that challenging training environments, whether individual or group-based and contact-intensive exercises such as those in neo gladiators practices (mixed martial arts), can foster conviction and drive. In our study, green exercise influenced the athletes' mental toughness, demonstrating that the environment and the type of physical activity played a role in psychological resilience.

In examining the differences in mental toughness results within this study, Scanlan et al. [44] found that pre-competition self-confidence was a strong indicator of

performance outcomes, effectively distinguishing between winners and losers. Confidence, a critical part of mental toughness [45], was higher among winners than losers. Similarly, Treasure et al. [46] observed that athletes with higher self-efficacy perceived competitive situations as less threatening than those with lower self-efficacy. Self-efficacy was a more robust predictor of performance when assessing process rather than win-loss outcomes. In our study, green exercise enhanced athlete C's performance, contributing to a first-place and gold medal by increasing mental toughness. Previous research supports a positive correlation between mental toughness and performance, with findings indicating that medallists in Wushu competitions and kickboxing winners showed higher mental toughness levels than non-medallists and losers, respectively [23, 47].

Additionally, age and gender may influence mental toughness. The participants in this study were 17 years old and had ten years of experience. Generally, older athletes tend to demonstrate greater mental toughness than their younger counterparts. As athletes age, they often develop advanced psychological skills and emotional maturity, which can enhance their mental toughness [48].

Training in taekwondo as well as in other non-indoor sports has a positive impact not only on mental aspects but also on somatic and fitness aspects [49].

This study has several limitations that should be considered when interpreting the results. Firstly, the study focused exclusively on a small group of elite athletes from Latvia, with no control group included. To improve the generalizability of future research, it is recommended to include more samples of athletes across various age groups. Another limitation is the short duration of the study, as the intervention was conducted only four weeks before the competition. Future research should explore the effects of green exercise over a longer period to understand better its impact on stress levels, mental toughness, and athletic performance. This study also measured stress levels and mental toughness among psychological factors. Future research should consider broader psychological and physiological factors..

5. Conclusions

Green exercise significantly improved stress levels based on the Determination Test but not on the DASS questionnaire or mental toughness metrics. Individual results showed varied stress reductions and mental toughness, suggesting the potential benefits of green exercise in competitive settings. Athletes showed excellent performance and great results in the competition. Further research is necessary on representative groups of athletes with different physical activity experiences, and other tests should be used to select a tool with the highest predictive value.

Data Availability Statement: The data supporting this study's findings are available from the corresponding author upon reasonable request.

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Conflicts of Interest: The authors declared no conflict of interest.

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